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Idaho Chemical Processing Plant Water Inventory Study Project Summary Report

1. INTRODUCTION

Discrepancies between the reported volume of water pumped from the Snake River Plain aquifer and the reported volume of water disposed of at the Idaho Chemical Processing Plant (ICPP) suggested that water was being lost from the ICPP plant water distribution and/or liquid-waste collection systems. This alone was not sufficient to generate concern as leaks in municipal and industrial water systems are common. However, in the past, there have been a number of releases of contaminants to the soil at ICPP. A concern was identified that if there was a significant volume of water leaking into the ground near the surface, contaminants could be leached and transported to the Snake River Plain aquifer. This concern was raised to the U. S. Department of Energy, Idaho Field Office (DOE-ID) by the State of Idaho, Idaho National Engineering Laboratory (INEL) Oversight Program.

In addition to the reported water volume discrepancy, additional information concerning potential water leakage was identified. Water seeps into vaults at the ICPP tank farm in quantities that exceed the expected volumes as stated in the ICPP tank farm safety analysis report. Also, a perched water zone has been identified at a depth of about 110 ft below land surface under the northwestern portion of ICPP. Most perched water zones at the INEL can be linked to surface water recharge from infiltration ponds (Cecil et al. 1991). The perched water zone under the northwest portion of ICPP is not directly linked to an infiltration pond and so leaks from plant water systems were considered to be a potential source.

To address this concern, a working group consisting of ICPP employees, the INEL Oversight Program, the U. S. Geological Survey (USGS), and DOE-ID was designated to investigate the potential for releases of water from ICPP facility operations. This report summarizes the work performed by that working group and presents the conclusions of the investigation.

1.1 Purpose and Scope of Study

There were two objectives of this study. The first was to determine if water was leaking from plant water supply and waste water systems in sufficient amounts to account for the seepage into the tank farm vaults and to support the deep perched water zone. The second objective was to resolve the overall water budget imbalance for the facility. A number of tasks were identified to address this issue:

- Evaluate water budget measurements and calculations for plant water systems
- Upgrade plant metering as necessary to quantify the plant water budget
- Leak-test plant water supply and waste water systems
- Estimate natural recharge
- Identify sources of water seeping into tank farm vaults.

Leak testing was confined to the northern portion of the plant as that was the area of concern for possible sources of recharge to the northwestern perched water body.

1.2 Uses of Information

Information from this investigation will be used by DOE-ID and WINCO plant managers to make decisions concerning the management of water and non-radioactive liquid-waste handling systems at ICPP. This investigation will also provide information concerning infiltration of water that can be used in assessing the risk posed by inactive hazardous waste sites for Federal Facility Agreement and Consent Order investigations at ICPP. Two groups will evaluate this information to make decisions concerning the need to implement changes at ICPP. Plant management within WINCO and DOE-ID will use the information to make decisions regarding plant system operations and design based on cost-effectiveness and impact on plant operations. The State of Idaho, the Environmental Protection Agency (EPA), and DOE-ID will use this information to make decisions concerning the need to implement remedial action based on the potential for release or mobilization of contaminants that might pose a risk to human health or the environment.

The State of Idaho, the EPA Region 10, and DOE have signed a Federal Facility Agreement and Consent Order that directs the assessment and remediation of past releases of hazardous wastes at the INEL. The decision mechanism to determine the need for remedial action is an assessment of risk following EPA guidelines. Results from this study will be one of many inputs to a remedial investigation currently being scoped for contaminated soils at the high level liquid waste (HLLW) tank farm and contaminated water in the perched water zone. Based on assessment of risk posed by this contamination, a decision concerning the need for remedial action will be made. The role that infiltration from the surface plays in mobilization and transport of contamination will be part of this decision.

1.3 Report Organization

The purpose of this report is to summarize the activities that have been conducted as part of the Water Inventory Study and to provide the results and conclusions of the investigation. Three other reports have been prepared during this investigation that provide more details than are contained in this summary report. The initial assessment of the water budget for the ICPP facility was reported in *Water Inventory Study - Progress Report* (WINCO 1993a). Details on the deficiencies in the metering system are in that report. For additional information on the leak testing of pipes, the reader is referred to *Idaho Chemical Processing Plant Water Inventory Study, Leak Test Report* (WINCO 1993b). For more detailed information on the analysis of seepage into vaults in the tank farm, the reader is referred to *Analysis of ICPP Tank Farm Infiltration* (Golder 1993).

Section 2 of this report briefly describes the important facilities at ICPP and the mission of the facility. A brief discussion of the occurrence of perched water at ICPP is also presented. Section 3 of the report discusses the water distribution and non-radioactive liquid-waste handling systems at ICPP. The systems considered important for this investigation are described, the water balance equation for the plant is presented, and results of the leak tests are summarized. Section 4 of the report discusses the analysis of seepage into vaults at the HLLW tank farm. The approach used in the analysis is described and conclusions arrived at from the analysis are presented.

2. BACKGROUND

This section presents a brief description of the ICPP and identifies key ICPP facilities. The occurrence of perched water at ICPP is also discussed.

2.1 Facility Description

The ICPP is located at the Idaho National Engineering Laboratory (INEL) in southeastern Idaho. The location of the ICPP is shown in Figure 2.1. Construction at ICPP began in 1949 and the facility was operational in 1954.

The ICPP was constructed to store and reprocess spent nuclear fuel from naval and research reactors. The primary purpose of the plant was to recover enriched uranium through dissolution of the fuel. In 1992, the mission of ICPP was changed to store and prepare spent fuel for final disposition. No fuel is currently being reprocessed at ICPP. The plant includes a variety of laboratory and reprocessing facilities, process chemical storage facilities, process chemical and waste transfer pipelines, process waste storage and disposal facilities, office and maintenance facilities, and non-process waste disposal facilities. Principal facilities at ICPP are identified in Figure 2.2. Plant activities involve the use of numerous chemical and radioactive materials, resulting in generation of a variety of hazardous, mixed, and radioactive wastes.

In the past, high-level-liquid wastes from the reprocessing facilities were sent directly to the tank farm for temporary storage. Approximately 200,000 gal/yr of HLLW were generated at ICPP when fuel was being processed (WINCO 1991). The tank farm consists of 19 storage tanks ranging in size from 18,400 to 300,000 gal. Liquid wastes are stored in the tank farm until the waste can be converted to solid form in the new waste calcining facility. In addition to high-level-liquid waste, sodium waste from decontamination activities is also sent directly to the tank farm.

2.2 Occurrence of Perched Water

Subsurface drilling investigations conducted at ICPP have identified perched groundwater beneath the plant. The primary perching layer occurs at a depth of about 110 ft below land surface. A number of perched water bodies exist below ground level at the ICPP (Figure 2.3). One perched water zone, at the southern end of ICPP, is fed by two percolation ponds used to dispose of industrial waste water from the plant (Cecil et al. 1991). There is also a perched water body at the northwestern corner of the ICPP facility. This second perched water zone is not linked to an obvious source of recharge. These two areas of perched water have been identified on the 110 ft interbed during drilling investigations. A third perched water body is presumed to exist under the sewage treatment ponds to the northeast of ICPP.

Perched water occurs when a sufficient amount of water moves downward through a higher conductivity zone and encounters a lower conductivity zone. This lower conductivity zone can be a fine-grained sedimentary interbed, a massive basalt flow, or the upper surface of a basalt flow where the fractures and pores have been filled with fine-grained sediments and secondary minerals. Therefore, "perching" of water often takes place within and above the interbeds where enough water is being recharged through the basalt. The most significant perching layer at ICPP is believed to exist approximately 110 ft below ground surface.

Perched water is found in a number of wells drilled in the northern area of the plant. The extent and continuity of the northwestern perched water zone is currently under investigation as part of the Federal Facility Agreement and Consent Order. This northwestern perched water zone is probably not continuous but consists of a number of smaller perched water bodies. Whether a single continuous perched water body, or a cluster of several smaller perched water bodies, this area of ICPP is underlain by more perched water than might normally be expected without a concentrated source of surface recharge. The northwestern perched water zone underlies a number of ICPP facilities and environmentally controlled areas where hazardous materials are known to have been released in the past, such as the tank farm. For the southern perched water zone, there is a clear source of water from the percolation ponds (Cecil et al. 1991). For the northwestern perched water zone, there is no such obvious source. This has led to speculation that releases of water from leaking pipes is responsible for the perched water under the northern portion of ICPP. The area of ICPP considered as most likely to contain a source of recharge for the deep perched water zone is shown in Figure 2.4. This area defines the scope of this investigation.

SOURCE: WINCO (1993)

FIGURE 2.3
**AREAS OF ICPP SPECULATED TO BE
UNDERLAIN BY PERCHED WATER**
EG&G/ICPP PERCHED WATER SUPPORT/ID

Golder Associates

3. PLANT WATER BUDGET

This section of the report discusses the water distribution and waste-water collection systems within the plant at ICPP. These systems have been leak tested to determine the quantity of water that could be contributing to tank farm seepage and the deep perched water zone. The volume of water available for recharge of the perched water zone from leaky pipes, other manmade sources, and precipitation are also estimated.

3.1 Plant Water and Waste Systems

The ICPP uses approximately 2.1 million gallons of water per day. Water is supplied by three wells: two raw-water wells and one potable-water well. A second potable water well is currently being drilled. The water is used for process cooling, equipment cooling, steam production, process solutions, decontamination, fuel storage basin makeup, chemical laboratory use, regeneration of ion exchange units, fire protection, and human uses such as drinking, personal showers, food preparation, and restroom facilities. Piping systems external to facility buildings are either buried or placed in utility tunnels. Tunnels provide easy access to the piping systems and act as a secondary containment allowing for continuous leak detection and monitoring. The ICPP systems considered relevant to this investigation are the raw water, fire water, treated water (softened), demineralized water, steam condensate, landscape watering, potable water, service waste (industrial wastewater), and sanitary waste. This section provides a brief description of each of these systems. Maps of the distribution and collection systems for the northern portion of ICPP are in Appendix A.

There are a number of other water and liquid-waste piping systems at ICPP. However, after evaluation of the characteristics of these systems, it was concluded that these additional systems were not considered to be possible sources of water to the perched water. Criteria used to exclude systems from this investigation were:

- Low volume of water in the system
- Lines enclosed in secondary containment
- System liquids contain a distinct radiological or chemical signature
- The system is closely monitored and or visible during daily operations.

Based on these criteria, three systems were excluded from the leak detection portions of the investigation. In addition, portions of other systems contained in utility tunnels were not included in the leak detection study. The three systems not subjected to leak detection were the steam distribution system, the HLLW process lines, and the pipes used to distribute cooling water to the HLLW storage tanks in the tank farm. Steam lines are under high pressure, and a leak would likely result in rapid erosion of soil with emergence of the leak at the surface. In winter, a leak would heat the soil resulting in an area where snow would not remain. Process waste lines used to transport radioactive liquid wastes are closely monitored for volume whenever transfers are made. Waste lines are enclosed in secondary containment, and any leaks would be caught in the secondary containment. The secondary containment is designed so that any leaks would flow to monitoring stations and be detected. The cooling system for the HLLW tanks is not currently used, but is maintained at operating pressures. The water level in the feed tank is monitored closely. Any leak would quickly be detected by a drop in the water level in the feed tank. Because a leak in any of these three systems would be rapidly detected, none were included in the leak detection investigation.

3.1.1 Raw Water System

The raw water piping system has an approximate total length of 6,250 ft with an average flow of 389 gpm. Figure A-1 shows the site plan of the raw water system. Raw water is pumped from the Snake River Plain aquifer from two production wells to the fire water storage tanks. Raw water overflows from the fire water tanks through internal stand pipes to two raw water feed tanks. The overflow stand pipes ensure that an adequate supply of fire water remains in storage at all times and allows flow through the tanks to prevent freezing.

The raw water feed tanks supply water to three raw water distribution pumps, which distribute raw water through the piping system to ICPP facilities. The raw water system also supplies water to softeners and demineralizers located in building CPP-606.

3.1.2 Fire Water System

The fire water piping system has an approximate total length of 5 miles with an average flow of about 45 gpm. This flow rate is not for fire suppression. There are a number of incidental uses for the fire water system such as lawn watering, safety showers, cooling of waste tanks and sump pump bearings, and to flush radiation monitor bowls. Figure A-2 shows the site plan for the fire water system in the northern portion of ICPP. Fire water storage tanks are supplied by the two raw water wells. The tanks supply water to fire pumps that distribute fire water to fire hydrants and fire protection systems.

3.1.3 Treated Water System

The treated water (softened) piping system has an approximate total length of 4,000 ft, with an average flow of 900 gpm. Figure A-3 provides the site plan of the treated water system for the northern portion of ICPP. Distribution of treated water begins at building CPP-606. Treated water is used for chemical process makeup and in heat exchangers to prevent scaling of heat transfer surfaces.

3.1.4 Demineralized Water System

The demineralized water piping system has an approximate total length of 4,200 ft, with an average flow of 1.5 gpm. Figure A-4 shows the site plan for the demineralized water system for the northern portion of ICPP. Distribution of demineralized water originates in building CPP-606. Demineralized water is used for process cooling, steam, and in the fuel storage basins.

3.1.5 Steam Condensate System

The steam condensate piping system has an approximate total length of 4,200 ft, with an average flow of 74 gpm between September and April. Figure A-5 shows the piping system for steam condensate in the northern portion of ICPP. Primary steam use occurs between the months of September and March due to seasonal demands such as heating and freeze protection. Steam is supplied from CPP-606 and the Coal Fired Steam Plant. Most steam generated at ICPP is condensed and recycled or routed to the service waste system. It is estimated that 10% of the steam produced is not recycled or routed to the service waste and is either released to the atmosphere or discharged to the ground.

3.1.6 Potable Water System

The potable water piping system has an approximate total length of 2 miles with an average flow of 61 gpm. Figure A-6 shows the site plan of the potable water system at ICPP. Potable water is supplied from the Snake River Plain aquifer by one potable water well. A second potable water well is being installed. Both wells will be used to supply potable water, with the existing well serving mainly as a backup to the new well. Water is pumped to the potable water storage tank. Three distribution pumps in building CPP-606 distribute the water to ICPP facilities. The potable water system also includes a chlorination system.

3.1.7 Service Waste System

The service waste piping system has an approximate total length of 2.4 miles with an average flow rate of 1,320 gpm. Figure A-7 shows the site plan of the service waste system for the northern portion of ICPP. The service waste system is a gravity fed system. Waste water in the pipes drains by gravity to lift station CPP-797, from which it is pumped to the percolation ponds south of ICPP. Service waste lines draining to the lift station are not under pressure. The line leading from the lift station to the percolation ponds is pressurized.

Raw water, treated water, demineralized water, and steam condensate are discharged to the service waste system. Waste streams that might be radioactively contaminated are piped through monitoring/diversion stations to monitor for radiological contamination before being discharged to the service waste system. If radiological contamination is detected, the waste water is directed to a low-level waste tank and stored for future processing. All water is monitored before being discharged to the percolation ponds.

3.1.8 Sanitary Sewer System

The sanitary sewer piping system has an approximate total length of 1.5 miles with an average flow rate of 29 gpm. Figure A-8 shows the piping network for the sewer system in the northern portion of ICPP. The sanitary sewer system is a gravity drained system. Sewage drains to lift stations by gravity, from which the waste is pumped to the ICPP sewage treatment plant.

Potable water and sanitary waste from various ICPP buildings are discharged to the sanitary waste system and flow to one of four lift stations. Each lift station has a sump and a pump which collect and transfer the sewage waste to the treatment lagoons.

3.1.9 Landscape Watering

There are seven systems in the landscape watering system, and all are in the northern portion of ICPP. The total area this system supplies is approximately 1.5 acres and total system flow approximately 20,000 gpd during the summer months. Each system is operated by an automatic timer set to operate the sprinklers at night. The landscape system is fed by the fire water system, raw water system, and the potable water system. The areas covered by the landscape system are shown in Figure A-9.

3.2 Plant Water System Budget

The water inventory for the ICPP facility was evaluated and documented in *Water Inventory Study - Progress Report* (WINCO 1993a). The study identified locations in the distribution system that required either the addition of flow meters or improvement in the accuracy of measurement at that point. In addition, a number of incidental, unmetered flows were identified. These incidental flows were estimated based on process knowledge. Six deficiencies were noted in the way in which the water budget at ICPP was measured and reported (WINCO 1993a). These deficiencies were:

1. The potable water meter was located approximately 2,200 ft away from the well, and down stream from the potable water storage tank. The meter could miss potential water losses between the well head and the start of the distribution system.
2. Only one of two discharge streams to the sewage treatment plant was measured.
3. The raw water meter was located approximately 750 ft from the well head and down stream of the fire water and raw water storage tanks. The meter could miss potential water losses between the well head and the start of the distribution system.
5. Approximately 300 gpm of raw water, used for heat pumps in four office buildings, was recycled back to the raw water storage tank and remetered.
6. There were a number of unmetered discharges.

To achieve the goal of upgrading the metering capabilities in the ICPP water system, a number of new meters have been installed to correct deficiencies identified during the water inventory study. Three new meters have been installed at the production wells (Figure 3.1). Two meters were installed on the raw water wells with accuracies of $\pm 0.5\%$. The average raw water production is 1,400 gpm and so the metering uncertainty is on the order of 7 gpm. A new meter was installed on the potable water line at a point that will measure flow generated by both the existing potable water well and the new well, after it comes on line. The meter installed on the potable water line has a metering uncertainty of $\pm 0.5\%$. The average flow from the potable water well is 60 gpm and so the metering uncertainty should be less than 1 gpm. Metering capabilities have also been added to the fire water system, raw water distribution line, and on the raw water recirculation loops on the heat pumps in four buildings.

To improve the measurements of flows leaving ICPP, a new measuring device was installed at the influent pipe to the sewage treatment plant. The flow to the sewage treatment plant will pass through a V-notch weir. The discharge will be quantified by measuring the water level in the channel and a rating curve developed for the weir. The level measuring device has an accuracy of $\pm 0.25\%$. The average flow to the sewage treatment plant is on the order of 29 gpm and so the uncertainty due to metering is on the order of 0.1 gpm.

In addition to the improved metering capabilities of ICPP inputs and outputs, other changes will be made to improve the accuracy of reporting to the INEL Nonradioactive Waste Management Information System (INWMIS). Production flow readings will be collected at approximately the same time and over the same time period as discharge readings are recorded. Also, the unmetered flows will be estimated and noted in the monthly INWMIS report. Even with the improved metering accuracy, an exact balance of the water equation at ICPP is not expected.

The improved metering accuracy will decrease the uncertainty in the water balance of the ICPP facility. Significant enhancements have been made by adding meters to previously unmetered flows. There are now very few outputs of water from ICPP that are not measured. These outputs are shown in Figure 3.1. The total estimated flow rate for these systems is on the order of 12.5 gpm in the winter and 26.5 gpm in the summer when the lawn sprinkles are in operation. The total flow through the plant is approximately 1,460 gpm, so this unmetered flow represents from < 1% (winter) to 1.8% (summer) of the total. Errors in these estimated amounts will not significantly affect the overall water balance.

3.3 Leak Testing

The leak test investigation was conducted to identify leaks in plant water and liquid-waste piping systems, and to quantify the contribution to the ground from any leaks detected. Because the primary concern of the project was the northwestern perched water body, the scope of the leak detection investigation was limited to the northern portion of ICPP (see Figure 2.4). This report summarizes the results of the leak detection program. A more detailed discussion of the project is given in *Idaho Chemical Processing Plant Water Inventory Study, Leak Test Report*, WINCO (1993b).

The systems considered as potential contributors to the northwestern perched water zone at ICPP are discussed in Section 3.1. Because both pressurized and non-pressurized systems were identified, more than one leak-detection method was required. Leak detection methods for each system were selected based on the design and characteristics of each system.

3.3.1 Test Methods

Different testing methods were required for the pressurized systems and for the gravity-fed systems. For the pressurized systems (raw, fire, treated, demineralized, steam condensate, and potable) leak tests were conducted using flow meters and/or by measuring the pressure decline in the system when it was isolated. For the gravity fed systems, a tracer injection method of leak testing was used.

3.3.1.1 Flow and Pressure Tests. For the pressurized systems, leak tests were conducted by flow testing or pressure testing. For the flow tests, all use of the system was shut off to the extent possible, and flow into the system was measured. For a system with no leaks, there should be no flow into the system when all uses are shut off. Pressure tests were conducted by pressurizing the line to be tested, shutting off all uses and the input to the line, and monitoring the pressure in the line over time. A line with no leaks would show no decline in pressure with time.

An ultrasonic flow meter was used for the flow tests. The ultrasonic flow meter provides a very sensitive measure of flow velocity in a pipe that is pressurized. The accuracy of the meter is $\pm 3\%$ for flows above 1 ft/sec and an accuracy of 0.03 ft/sec for flows below 1 ft/sec. The discharge through the pipe is then calculated by multiplying the velocity by the cross-sectional area of the pipe. The flow meter can be used on pipes made of metal, plastic, glass, and mandrel-wound fiberglass reinforced plastic.

Flow tests were conducted by measuring the flow in a pipe system after all, or as many as practicable, water uses in the system were shut off. If all uses of water could not be shut off, then the flow for these uses was estimated. The flow meter would be installed on a pipe at the inlet to the portion of the pipe system to be tested. If there were no leaks in the system then the flow through the pipe would be zero, or approximately equal to the estimated uses. Flow in the pipe in excess of these

amounts would indicate a leak, and the volume of the leak could be calculated from the measured flow rate.

For some systems, the flow meter could not be installed at the inlet to the system. In these cases, water was supplied to the system from an external source with a hose. The flow rate from the external source was measured to quantify any leaks.

Some systems were pressure tested by isolating the piping system while under pressure and monitoring the line pressure. All use of water in the system had to be shut off for this method to work. Once the system was pressurized, the inlet to the portion of the system to be tested was also shut. A drop in pressure indicated a leak. The rate of the leak could be calculated from the rate of pressure drop and the volume of the pipe. This type of pressure testing is very quick, although calculation of the leak rate requires the volume of the pipe system be known. This method was also used in conjunction with the ultrasonic flow meter where the pipe was tested for leaks with the static pressure test, and, if a leak was identified, the leak rate quantified with the flow meter.

A variation on the pressure test was performed by using a hydraulic head applied to the system to pressurize the line. A vertical stand pipe was attached to the pipe network to be tested, and the stand pipe filled with water. If a leak existed in the pipe network, water would drain out of the stand pipe to replace water lost to the leak. The rate of water loss from the stand pipe would be a measure of the rate of leaking from the pipe network.

3.3.1.2 Tracer Tests. For systems that are not pressurized, pressure and flow rate tests cannot be used. The nonpressurized systems of concern for this investigation are the sanitary waste system and the service waste system. To test these systems, a volatile organic tracer was added to the liquid in the line. The soil outside the line was monitored for the tracer to determine if there was a path for the tracer inside the pipe to leak out. Tracer in the soil gas would indicate that a leak existed in the pipe.

To perform this test, a volatile organic tracer was added to waste waters being discharged to the service waste and sanitary waste systems. A different tracer was added to each system so that the test could tell which of the two systems was leaking. The organic tracer would evaporate from the waste water inside the pipes forming a gas. If there were any leaks in the pipes, the tracer could leave the pipe by one of two paths. The tracer gas could diffuse through holes in the pipes to the soil outside the pipe. Alternatively, tracer could evaporate directly into the soil gas from water that had leaked out of the pipe. The design criteria for the tracer test was to detect a leak of 1 gal/day. To do this, the concentration of tracer in the liquid-waste inside the pipe was adjusted so that a leak of 1 gal/day would result in a detectable quantity of tracer being released to the soil gas.

Sampling probes were installed every 5 to 15 feet along the service waste lines and sanitary waste lines in the area of concern. The probes were installed to a depth that was approximately 2 ft above the service waste lines and 5 ft above the sanitary waste lines. The probes are 1.5 in. diameter steel pipes, open at the bottom. Gas from the soil immediately above the waste line can be pulled through the probe and sampled at the land surface. Fourteen days were allowed between the time the tracer was injected into the waste lines and samples were collected from the soil probes. This provided time for the tracer to diffuse out of the pipe and into the soil. If tracer is detected in the gas pulled from a soil probe then a leak in the vicinity of that probe is indicated.

3.3.2 Results of Testing

3.3.2.1 Raw Water System. Most of the raw water system in the area of interest was hydrostatically tested in 1992. Review of these test results indicated that data from this 1992 test were useable for this project. Only one line of interest had not been tested in 1992. That line was pressure tested during this investigation and found to hold pressure for 30 min. Based on the 1992 testing and the testing for this investigation, there are no leaks in the raw water system in the northern portion of ICPP.

3.3.2.2 Fire Water System. The fire water system is very large, and so was tested in sections. The total water flow into the fire water system was measured while various subsections of the system were valved out. Any change in flow rate was noted when each valve was closed. There was an average flow rate of 45 gpm in the fire water system from normal uses that could not be interrupted while this test was being conducted. Based on the incremental testing of the pipe network, it was concluded that there was a leak in the fire water system within the area of interest. By further isolation of lines, it was determined that the fire water line along Beech St. between Cyprus Ave. and Olive St. was leaking at a rate of 16 gpm. Two leaks were identified along this stretch of pipe: a 4 gpm leak at a fire hydrant and a 12 gpm leak in the service line to CPP-751. The 4 gpm leak was repaired at the time it was detected and a work order has been issued to fix the line into CPP-751.

3.3.2.3 Treated Water System. This system was tested by measuring the flow into the distribution lines during a 14 min complete shutdown of all uses of treated water. No flow was detected in the distribution line indicating no leaks in the treated water system.

3.3.2.4 Demineralized Water System. The demineralized waste system was tested by measuring the flow in the main distribution line from building CPP-606. During a complete outage of the system when all uses had been shut off, flow measurements on the line varied between 0 and 0.3 gpm, the limit of detection of the flow meter. The conclusion of this test is that there are no significant leaks in the demineralized water system.

3.3.2.5 Steam Condensate System. The portion of the steam condensate system located in the area of interest is housed entirely in the utility tunnel and could be inspected visually. There is a buried steam condensate line that runs to the west of building CPP-606. This line could not be shut down for testing during this investigation because of heating and freeze protection requirements. This line is also mostly outside the area of interest shown in Figure 2.4.

3.3.2.6 Potable Water System. The potable water system was tested in three sections. The first section was from the production well to the storage tank, the second section was from the storage tank to the head of the plant distribution system in CPP-606, and the third section consisted of the entire distribution system within the plant.

Testing of the line that runs from the production well to the storage tank identified a leak of 0.15 gpm when the well was pumping. The line from the storage tank to CPP-606 was found to be tight.

The plant distribution system could not be completely shut down for this test. Therefore, potable water flow into the distribution system was measured during the midnight to 7:00 AM shift for a period of one week. Flows for the midnight to 7:00 AM time period ranged between 6.4 gpm and 7.6 gpm. Because the system could not be shut down completely, the expected volume of flow was estimated. This was done using American Society of Civil Engineers criteria for potable water and

sanitary sewer systems. There are between 100 and 200 workers in the plant on the midnight shift. Engineering design guidelines (ASCE 1982) indicate an average consumption of 30 to 60 gal per person per 8 hr shift. The expected flow for the potable water system would therefore be between 6.25 and 25 gpm. In addition, there may be internal system losses such as leaky faucets and running toilets that consume a few gpm. The flows measured in the potable water system are consistent with anticipated use and there is no indication of a significant leak in this system.

3.3.2.7 Service Waste System. Leak testing of the service waste line was accomplished using the tracer leak detection method. No tracer was detected above the quantitation limit in any of the sampling probes indicating that there are no leaks of 1 gal/day or more in the service waste system in the area of interest. The tracer leak testing method only provides information on releases from the pipe, and does not provide information concerning the strength and integrity of the pipe itself. In the past year, three leaks in the service waste line have been identified and repaired. Therefore, this pipeline may be susceptible to leaks whenever the system is pressurized to the point of stressing the pipe. The service waste system does not seem to be a source of continuous leakage, but may be a candidate for periodic releases caused by failures in the line in response to pressure changes (WINCO 1993b).

3.3.2.8 Sanitary Sewer System. Leak testing of the sanitary sewer system was accomplished using the tracer leak detection method. The tracer used to inoculate the sanitary sewer system was not detected in any samples. This indicates that there are no leaks in the sanitary sewer lines tested by the tracer injection method. Similar to the service waste system, the test method does not provide information on the physical condition of the pipe.

3.3.3 Conclusions from Leak Testing

ICPP water and waste piping systems have a total length of about 15.4 miles within the plant. Of this length, about 5 miles of piping were evaluated for leaks in the northern portion of the plant. Most of the systems were found to be tight with no leaks. The fire water system and the potable water system were found to be leaking.

The fire water system was found to have a 4 gpm leak, which was assumed to be a year round leak, and a 12 gpm leak from a branch connection that is used only periodically. Use of this branch was estimated to be 48 hr/week. The potential loss from leaks in the fire water system was calculated to be 3.9 million gal/yr. The pipe leading from the potable water production well to the water storage tank was found to have a small leak of 0.15 gpm at the production well. This is calculated to provide 79,000 gal/yr of potential recharge.

Most of the leak tests were very conclusive. Pressure tests showed that lines held pressure for 15 to 30 min without loss. Flow tests showed no significant, unaccounted flow in lines when all uses were shut off. Tracer tests showed no leaks greater than 1 gal/day. The uncertainty from these tests is very small. The one system with the most uncertainty is the potable water distribution system. The system could not be shut off completely, and the conclusion that there were no significant leaks in the distribution system was based on estimated uses of potable water. These tests were run when the total flow in the system was small (6 to 7 gpm). Based on a comparison between the estimated use and measured use, it is unlikely that a leak in excess of 1 or 2 gpm could exist in the potable water distribution system. The total flow through the ICPP water and waste system is on the order of 1,460 gpm (2.1 million gpd). About one-third of the system is in the area of interest, so one-third of the

total flow is about 490 gpm. An uncertainty of 2 gpm is less than one-half of one percent of the flow through the system in the area of concern.

Leaks in the fire water and potable water systems identified during this investigation are being repaired. In general, the water and waste distribution systems at ICPP are not leaking. The total estimated volume of water available from leaking pipes in the northern portion of ICPP is 3.98 million gal/yr.

3.4 Landscape Watering

There are seven lawn areas at ICPP that are watered during the summer months. Locations of these areas are shown in Figure A-9. Different systems supply water to these sprinkler systems including the fire water system, the raw water system, and the potable water system. The volume of water applied to these areas was calculated by determining the flow rating for each sprinkler head (in gpm) for line pressures at ICPP and multiplying that number times the number of minutes the sprinkler systems are run. During the summer months, approximately 20,000 gal per day are applied to lawns. The total volume of water that is supplied to the seven lawn water stations between April and October is 2,352,000 gal (WINCO 1993b).

Consumptive use by the lawns was calculated from Bureau of Reclamation daily recorded values for consumptive use and evapotranspiration for grass crops in the Aberdeen area of southeastern Idaho. A volume of 784,000 gal per growing season was calculated (WINCO 1993b). Subtracting the consumption and evapotranspiration from the supplied water gives a net volume of 1,568,000 gal per year available for infiltration.

3.5 Natural Recharge

In this section, the volumes of water from precipitation available to support a deep perched water zone are estimated. Because of the many impermeable areas within the ICPP facility (roofs, roadways) a significant fraction of the total precipitation input runs off to drainage ditches. The drainage ditches are unlined and a significant fraction of the infiltration likely occurs along these ditches. It is beyond the scope of this report to provide a detailed spatial evaluation of infiltration. The amount of infiltration can be bounded to provide estimates of the water available for seepage into tank farm vaults and to the deep perched water.

The INEL is in a desert climate with low precipitation and high evaporation. The long-term average annual precipitation at Central Facilities Area (CFA) is 8.7 inches (Clawson et al. 1989). Estimated pan evaporation is on the order of 43 inches per year. Therefore, there is an overall net water deficit for the Site. Because of the cold winters, however, a snow pack usually develops which results in a period of high recharge in the spring when evaporation is low. If the spring recharge infiltrates to a sufficient depth, it may not be re-evaporated during the summer and may recharge perched water zones and the Snake River Plain aquifer. Studies of this phenomenon have been conducted at the Radioactive Waste Management Complex (RWMC) and at the CFA landfills. Data and reports from these two facilities were reviewed and conclusions documented. Comparability of these facilities with conditions at ICPP was evaluated to determine the applicability of the conclusion to the tank farm.

3.5.1 Evaluation of Applicability

For results of these investigations to be applicable to ICPP, a number of criteria would have to be met. These include:

- Surface materials should have the same moisture-retention characteristics as those at ICPP.
- The scale of the investigation should be roughly the same scale as the area of interest at ICPP.
- For large scale infiltration, characteristics such as impermeable areas and drainage ditches should be taken into account.

Based on these criteria, it is concluded that the studies that involve the movement of tritium and chlorine-36 in surface soils at the RWMC (Cecil et al. 1992) are not applicable to ICPP. Surface soils at the RWMC are clayey silts, while surface soils at ICPP are gravelly sands. Also, the study was conducted at a single point, and does not evaluate spatial averaging effects. Because of the material property differences, the estimates from the chlorine-36 and tritium tests cannot be applied to ICPP.

Estimates of flux made by Magnuson and McElroy^a were from data collected at the RWMC. The measurements were made at depth, and so integrate a fairly large area above the measurement point. The RWMC is drained by a series of drainage ditches that collect runoff and concentrate water in certain areas. The RWMC has very little impermeable area such as pavement or buildings. Surface materials at the RWMC are fine-grained, very different than the coarse-grained materials at ICPP. Because these data represent a fairly large area, which integrates a wide range of surface characteristics, the differences in surface materials may be of less importance than for a study conducted within the dissimilar surface materials. Therefore, although there are differences with the RWMC, the estimates of Magnuson and McElroy may be reasonable for application to ICPP.

An infiltration study conducted by Miller et al. (1990) at CFA Landfill II was based on calculated evapotranspiration, which involves many assumptions. The material properties used in the calculations are probably very similar to those at ICPP because both sites are located on alluvium from the Big Lost River. Calculations concentrated on the top 1.5 to 3 ft of sediments. Neutron measurements by Ansley et al. (1988) indicate that the active evapotranspiration zone is more like 5 to 7 ft thick. This would increase the amount of storage in the calculation of net infiltration and decrease the amount of net infiltration. The investigation evaluated an area of 5.9×10^5 ft², which integrates a variety of surface conditions. There are no impermeable areas or drainage ditches at CFA Landfill II. Because of the similarity in material properties and the area of the investigation, the estimates of infiltration from Miller et al. (1990) are considered the most applicable of the available INEL values to ICPP.

a. Magnuson, S. O., and D. L. McElroy, *Estimation of Infiltration from In Situ Moisture Contents and Representative Moisture Characteristic Curves for the 30 ft, 110 ft and 240 ft Interbeds*, Engineering Design File RWM-93-001.1, August, 1993.

3.5.2 Discussion

The estimates of net recharge from Magnuson and McElroy and Miller et al. (1990) range from 1 to 4 in. per year. The average net infiltration from Miller et al. of 1.63 in. per year is considered to be the best estimate of net infiltration for use at ICPP. Because of impermeable areas and a drainage system that collects runoff in infiltration ponds, the total infiltration from the ICPP area may be larger. The spatial distribution of that infiltration, however, would not be uniform. Flat areas would have infiltration rates similar to those determined for the CFA landfills. Infiltration would increase along drainage ditches, and be greatest beneath infiltration ponds used to collect runoff.

The total volume of infiltration in the northern end of ICPP was estimated using a net infiltration rate of 1.63 in/yr. The area considered to be the recharge area for the northern perched water zone is about 87 acres. The volume of water is estimated to be 4 million gal per year.

3.6 Conclusions

Three primary sources of recharge to the deep perched water zone under the northern portion of ICPP have been identified. These are:

- Leaks in water distribution systems
- Irrigation of landscaping
- Infiltration of precipitation.

The total amount of water available as recharge is 9,548,000 gal/yr (Table 3.1). Of this, about 42 % comes from leaks, 42 % from natural recharge, and 16 % from irrigation. The leak testing found very few leaks, and of relatively small volume. However, even at these low rates, leaking pipes contributed a significant portion of the total recharge. Repair of these pipe leaks will reduce total infiltration significantly.

Table 3.1 Estimated volumes of recharge to the northern perched water body.

Source	Volume (gal/yr)	Percent of total
Leaks	3,980,000	42 %
Landscape irrigation	1,568,000	16 %
Infiltration of precipitation	4,000,000	42 %
Total	9,548,000	100 %

4. TANK FARM VAULT SEEPAGE

This section of the report addresses water seeping into underground vaults which contain high-level liquid waste (HLLW) storage tanks at ICPP. Each of the vaults contains from one to three sumps. The purpose of the sumps is to serve as a backup leak detection system for release of HLLW from the storage tanks. Primary leak detection for the HLLW storage tanks is based on measuring the level of liquid inside the tank. The source of water leaking into the vaults was raised as a concern by the State of Idaho INEL Oversight Group because this source could also be leaching contaminants released to soil in the vicinity of the tank farm and transporting contaminants to the aquifer. This section of the report evaluates information concerning patterns of seepage into vault sumps, the chemistry of water in sumps, and the water balance for the tank farm to determine the sources of water seeping into the vaults. A more comprehensive discussion of this analysis is provided in *Analysis of ICPP Tank Farm Infiltration* (Golder 1993).

The report addresses the underground vaults which contain the eleven 300,000 gal HLLW storage tanks. There are a total of eight vaults. Four of the tanks are contained in one large, square vault (713) that is divided into four chambers. Water has seeped into the vaults since they were first constructed. The first vaults contained one small sump. In later vaults, two sumps were installed to hold more water. In the last two chambers of vault 713 constructed, three sumps were installed, one of which was specifically designed to collect seepage from outside the vault. The current rate of seepage to all the vaults is about 29,000 gal per year. This is slightly above historical trends, but is not very different than rates that have been observed over the past 25 years.

4.1 Description of Tank Farm and Vaults

4.1.1 HLLW Tank Farm

The HLLW tank farm receives liquid radioactive wastes for temporary storage until the wastes can be solidified in the waste calcine facility. The tank farm consists of a number of stainless steel storage tanks with capacities ranging from 18,400 to 300,000 gallons (Figure 4.1). Eleven of these tanks each have a capacity of approximately 300,000 gallons and are used to store the bulk of the liquid wastes. The stainless steel tanks are contained in underground concrete vaults (Figure 4.1). Vaults numbered 780 through 786 contain tanks numbered WM-180 through WM-186. Tanks numbered WM-187 through WM-190 are contained in vault 713. The tops of the tanks are approximately 10 ft below land surface (bls), with their bases located approximately 50 ft bls. In 1977, the tank farm was graded to promote drainage and covered with a synthetic membrane to inhibit water infiltration. The membrane is covered by approximately 6 in. of gravel.

4.1.2 Vault and Tank Construction

The vaults vary in details of design and construction. The general configuration of the vaults and tanks, however, share many similarities. A general drawing of the vault and tank construction details is shown in Figure 4.2. Vaults 780 and 781 are made of cast-in-place concrete and are octagonal in shape. The roofs of these vaults are different than the roofs of the other vaults. Vaults 780 and 781 have hunched roofs consisting of a 1.25 ft thick concrete slab supported by the hunched roof girders. Vaults 782 through 786 are constructed of pre-cast concrete columns and panels. The seams between the columns and panels and the panels and the floor are sealed with grout. The remaining tanks, WM-187 through WM-190, are enclosed with a single, rectangular, continuous pour concrete vault (713) with partitions separating the tanks. All of the vaults are constructed on 2.5- to 3-ft thick

concrete slabs placed directly on bedrock. The walls range in thickness from 6 in. for the pillar and panel vaults, to 42 in. for the rectangular continuous-pour concrete vault. The roofs of vaults 782 through 786 and vault 713 consist of concrete panels resting on concrete beams which extend across the vault (Figure 4.2). Tanks in vaults 713 and 782 through 786 are placed on sand pads to distribute the load on the bottom of the tank.

The liquid-waste tanks are 50 ft across by 32 ft high. All the tanks are built of stainless steel. Most tanks contain cooling coils to carry away the heat generated by radioactive decay within the tanks. The composition and volume of waste within the tanks changes depending on fuel reprocessing and waste calcining activities. In the past, waste inside the tanks consisted mainly of solutions remaining from the dissolution of spent nuclear fuel. The solutions were very acidic, containing nitric, sulfuric, and hydrofluoric acids. Solutions also contained high concentrations of fission products (particularly Cs-137 and Sr-90), uranium isotopes, and transuranics (plutonium, neptunium, and americium). Solutions are also high in heavy metals, such as mercury and cadmium. Most of the fuel reprocessing wastes have been calcined, and the remaining HLLW in the tank farm is primarily sodium waste.

4.1.3 Vault Sumps

Each vault has from one to three sumps to collect any liquid which enters the vault. Liquid levels in the sumps are monitored and if the level rises above the alarm level within a vault, the liquid is removed by jetting with a steam or air line. All four chambers of vault 713 contain two hot sumps where liquid is collected that may enter the vault or come from the sand pad beneath the tanks. The two eastern chambers of vault 713 (for tanks WM-189 and WM-190) also contain a 36 in. by 60 in. cold sump that has a depth of 9 ft. This sump is designed to collect liquid that enters the vault outside of the tank area. The area that drains to the cold sump is separated from the drain trench to the hot sumps by a six-in. high curb.

Between June 1990 and April 1993, an average of 2,473 gallons of water per month were jetted from the tank farm vaults. The distribution of seepage into tank farm vaults is not uniform. Most seepage occurs at the eastern end of the tank farm into sumps in vault 713. Figure 4.3 shows the average annual volume of water jetted from the sumps between 1990 and 1993.

4.2 Possible Sources and Characteristics

A review was conducted of the potential sources of water for the seepage. This included waste handling systems (such as waste transfer lines and leaks from the tanks), tank support systems (including cooling water and steam lines), man-made sources (such as potable water, raw water, sewage, and service waste lines), and natural sources (precipitation). For each possible source, characteristics describing the source were developed. Four characteristics were defined:

- **Pattern** – the pattern each source would produce in seepage was determined. Patterns were determined to be constant, precipitation related, seasonal, or random.
- **Chemistry** – the chemical signature of the sources was evaluated to determine if there were chemicals that would uniquely identify sources.
- **Location** – the spatial relation and proximity of sources to vaults was determined.

- Volume – the potential volume of water a source could generate was evaluated and compared to the volume of seepage observed.

In addition to sources, pathways that water could take to enter the vault were developed. There were four possible pathways identified:

- Through the roof – most vaults have roofs constructed of beams and panels, with the potential for a crack in the seal between the panel and beam. This provides an opening that water can seep through.
- Through the walls – water could seep through the wall of the vault if a perched water table developed at the sediment-basalt interface outside the vault. Many of the vaults are constructed of pillars and panels with joints between the panels.
- Along pipe encasements – pipe encasements drain to monitoring stations where releases from pipes can be detected. The monitoring stations then drain back to the vaults so that releases from the pipes are contained. Water entering the pipe encasements could flow to the monitoring stations and then to the vaults.
- Release within the vault – some of the potential sources, particularly the support systems sources, could release directly into the vault and would not require a pathway into the vault.

Once the characteristics of the sources and pathways were determined, information about seepage into the sumps was compared to these characteristics. Figure 4.4 illustrates the sources and pathways.

4.2.1 Waste Handling Sources

Sources that are included in the waste handling category are:

- HLLW tanks
- Waste transfer lines
- Valves in waste transfer lines.

One possible source of water to the sumps is the high-level-liquid waste stored in the tank farm. The waste storage tanks in the vaults have never leaked. The waste-transfer lines have leaked in the past, and the valve seals on the waste-transfer lines have been replaced because they leaked. Secondary containment for the waste-transfer lines drains to monitoring stations along the pipes. Most of these monitoring stations then drain to tank-farm vaults where the leaking water enters the vault sumps. Any leaking waste-transfer pipes or valves in the tank farm are repaired immediately. All waste transfers within the tank farm are monitored for volume at the source and at the receiving end of the transfer to assure that the entire volume transferred is received. In addition to the water released by the leak, the pipe or valve must be decontaminated before repair. This usually takes about 100 gal of water which drains to the vault sumps.

The waste storage tanks are continuously monitored for water level inside the tanks. No leaks have been detected in tanks. The resolution of water level monitoring equipment in the tanks is ± 0.16 in. The tank diameter is about 50 ft, and so a change in volume of up to 200 gal might not be detected immediately. However, a leak would result in a trend in water level measurements that could be

detected. Leaks from HLLW storage tanks could not generate the volume of water that is removed from the tank farm vaults without being detected by tank-level monitoring instrumentation.

HLLW contains very high levels of dissolved solids, high concentrations of radionuclides, and is extremely acidic. HLLW in water removed from vault sumps would contribute significant levels of contamination that would be detected by an analysis of water samples. However, because transfer-line valves have leaked in the past and through other mechanisms, some of the vault sumps are already contaminated. After the mid-1970s, radiation monitors were installed to detect leaks in valve boxes. In the late 1980s, new radiation monitors were installed. There have been two leaks since 1989 and both were detected quickly.

4.2.2 Support System Sources

There are two support systems that bring water into the tank vaults. These two support systems are the cooling water system to cool the waste tanks and the steam lines used to transfer waste and to purge the sumps. Many of the HLLW tanks contain cooling coils to reduce the temperature within the waste tanks due to radioactive decay. Currently, none of the tanks require cooling and so the system is not operating. Water is maintained in the system and monitored periodically for leaks. Water levels in the cooling water system have not declined indicating no leaks in the system. The cooling water is made up of demineralized water with potassium dichromate maintained at 500 ppm to prevent corrosion.

Steam jets are used to transfer HLLW out of waste tanks and to transfer liquid from the vault sumps. Steam valves have leaked in the past resulting in steam condensate entering the vault sumps. This type of leak is very easy to detect because the leaking valve becomes hot from the leaking steam. Therefore, while this has been a source of some leakage to the vault sumps in the past, it is a source that is easily detected and corrected. Some steam condensate is released to the land surface near buildings 628, 635, and 636. The steam condensate is hot and generally evaporates quickly. Leakage from these valves is estimated to be on the order of 5 gallons per month.

4.2.3 Man Made Sources

Water is used for a variety of purposes at ICPP and transported about the plant in a number of distribution systems. Within the vicinity of the tank farm are a number of water systems:

- Service waste
- Potable water
- Sewage
- Fire water
- Landscape applications

Service-waste lines are used to transport industrial waste water from various processes to the percolation ponds at the south end of ICPP. There are two service-waste lines in the vicinity of the tank farm (Figure A-7). One, very small line, carries steam condensate generated by the steam jets across the north end of the tank farm and connects to the main service-waste line along Beech Street, west of the tank farm. A second service waste line exits the north side of the PEW evaporator building (CPP-604), and flows west along the south side of the tank farm to Beech Street. The chemistry of the service waste is variable depending on the process. Service-waste lines generally are not pressurized, that is, they are only partially filled with water.

There is one potable-water line near the tank farm (Figure A-6). This line feeds building CPP-699, immediately east of the tank farm. This is a fairly new line and is pressurized. The proximity of this line to vault 713, which has the greatest leakage, makes it potentially suspect. Potable water is pumped from the Snake River Plain aquifer.

Sewage from ICPP flows in ceramic-tile sewer lines to pump stations where it is pumped to a sewage treatment plant just east of ICPP. The nearest sewer lines to the tank farm are approximately 200 ft north of the northern tank farm boundary (Figure A-8).

Fire-water lines run adjacent to the southeast corner of the tank farm and along the eastern boundary (Figure A-2). The line was pressure tested in 1991 and found to be sound. Fire water is provided from the raw-water system and pumped from the Snake River Plain aquifer.

Building CPP-699, just east of the tank farm, has a lawn that is watered (Figure A-9). This lawn is about 45 ft east of the tank vaults. Discussions with WINCO personnel indicate the lawn is currently watered for seven minutes once a day, usually at night. The depth of applied water was measured and found to be 0.375 in. or 0.054 in./min. In dry years, the lawn is watered for 10 to 15 minutes twice per night. This watering takes place every night for seven nights a week. Given the surface area of approximately 2,970 ft² and approximately 0.375 in. of water being applied to the lawn surface, approximately 700 gallons of water is currently applied to this lawn per day or 21,000 gallons per month. In dry years, given 30 minutes of watering per night approximately 3,000 gallons of water are applied to the lawn per day. The lawn is watered from mid-April to mid-October.

4.2.4 Natural Sources

Water is added to the tank farm in the form of precipitation. The total amount of precipitation averages about 8.7 in. per year (Clawson et al. 1989). There is generally greater snow drifting on the east side of the tank farm around the access hatches and valve boxes over vault 713. Therefore, water available from precipitation may be locally heavier in this area of the tank farm. The area of the tank farm is approximately 100,000 ft² giving a potential volume from precipitation of over 500,000 gal per year. Run-on to the tank farm from surrounding areas and buildings could increase this number somewhat. This water could infiltrate into the soil, and then into the tank farm vaults. The tank farm is covered with an impermeable membrane. A dye tracer study in 1981 showed that lateral migration from drainage ditches surrounding the tank farm did reach cold sumps for tanks 189 and 190. Therefore, water can move laterally under the membrane to the vaults.

During November, 1973, the WM-190 tank vault was opened and entered for inspection of water sources entering the vault^b. The date of the entry is not given in the report. There were 1.02 in. of rain in the first two weeks of November, 1973 (Miller et al. 1990) with one storm of 0.48 in. on November 12th. Personnel performing the inspection noted that water was entering through tank riser structures and through the roof beam-to-wall joints (see Figure 4.2). They did not observe any evidence of seepage through the vertical walls or through the wall-to-base slab joint. This inspection indicated that most of the seepage was dripping from inadequate roofing seals onto the top of the tank and then draining into the vault cold sump (190 C). The investigator indicated the seepage was due to water trapped on top of the roof beams. This inspection was performed prior to the installation of

b. Allied Chemical Corporation, written communication, ECP Production Monthly Report No. 164, October 27 - November 26, 1973, December 5, 1973.

the impermeable membrane in the tank farm area. Precipitation may be entering the tank farm through breaks in the membrane for piping, vents, manholes, and other protrusions to the tank farm surface.

4.3 Characteristics of Seepage

This section discusses the analysis of seepage characteristics that were conducted. These characteristics include pattern over time, chemistry, proximity of sources, and the volume available from sources.

4.3.1 Patterns

One characteristic of seepage is the pattern the seepage displays over time. Continuous seepage would suggest a constant source such as a leak from a pipe that always carried water. Seepage that increased in the spring would suggest a relation to precipitation. Seasonal variations would be expected for a precipitation-related source as summer evaporation dried out the soil. The dry soil would hold onto the precipitation, decreasing the precipitation-seepage response in the summer. Some sources might also be seasonal, such as watering the lawn in back of CPP-699. Finally, many of the sources would produce a random pattern in seepage, with occasional leaks or releases.

Water levels in the sumps within the vaults are continuously recorded by ICPP operations. Graphs of the sump water levels were printed out from the data stored on computers at ICPP for the period between January 1989 and June 1993. Using the graphs, the total monthly inches of rise in the water level of each sump was determined by subtracting the water level at the beginning of the month from the water level at the end of the month. Any changes in water level from jetting water out of the sump were also included. This provided information on the amount of water seeping into the vaults each month as well as accurately reflecting when the water seeped into the vaults. Cumulative seepage plots for the sumps are shown in Figures 4.5 to 4.9.

To evaluate the patterns in seepage, a least squares multiple regression approach was used to fit a model equation to the seepage data. Data used in the analysis consisted of the inches of water seeping into each vault per month. The time period used in the analysis was January 1989 through June 1993. For most vaults, only one sump was analyzed. This was because the second sump showed either no response to seepage, or because both sumps showed parallel response. Three vaults were not analyzed (780, 781, and 782) because there was so little seepage into these vaults that patterns could not be meaningfully determined. For two of the chambers in vault 713 (713/189 and 713/190), two sumps were included in the analysis.

The overall model of seepage is based on the four patterns discussed in Section 4.2. The patterns included in the equation are constant, seasonal, recharge related, and random. The equation that describes this model is:

$$S = C_0 + C_1 Q^n + C_2 \sin\left(\frac{2\pi t}{12} + \alpha\right) + \epsilon$$

where:

$$\begin{aligned} S &= \text{Total monthly seepage (in.)} \\ C_0 &= \text{Constant monthly seepage} \end{aligned}$$

C_1	=	Response factor to recharge
Q	=	Recharge (in.)
n	=	Exponent for non-linear relation to recharge
C_2	=	Response factor to seasonal fluctuations
t	=	Time (months)
α	=	Lag time (radians)
ϵ	=	Residual variation

Some of these terms need some further explanation. The recharge component was considered to be potentially nonlinear. That is, there may not be a simple 1 to 1 relation between the amount of recharge and the amount of seepage. Small recharge events may not reach the vault because of soil moisture storage. For larger events, the percentage of recharge reaching the vault may increase as the total amount increases. Therefore, recharge was permitted to have an exponent different than one. After fitting data with a number of exponents, an exponent of 2 was found to provide the best fit for the most sumps. For three sumps, a slightly better fit was obtained by using a linear or cubic exponent. Because the improvement was small, all sumps were fit using recharge squared to provide comparability between sumps.

The seasonal variation is modeled using a sine wave. Monthly data are used, and the data therefore go through one cycle (2π radians) in 12 months. The cycle does not necessarily start at 0 in January, and so a phase shift angle, α , is included. For a seasonal cycle caused by evaporation drying of soil, it would be expected that the maximum of the cycle would be in the spring, and the minimum would be in the fall. If the cycle deviates from this expectation, then some other process may be influencing the seasonal cycle. For example, if watering the lawn behind CPP-699 provides significant seepage to a vault, then the maximum would occur in late summer rather than the spring.

The regression model showed that all vaults analyzed have a significant contribution from precipitation. This consisted of a precipitation response coefficient and a seasonal cycle that modified the precipitation response. The cycle reached a maximum in the spring (about April) and reached a minimum in the early fall when soil was driest. For most of the vaults, spring recharge was the only source of seepage into the vaults. This could be seen in cumulative seepage plots with sharp increases between March and June each year, and no seepage in the remaining months of the year.

For the sumps in vault 713, however, the pattern of seepage was different. These sumps still demonstrated a significant precipitation response coefficient, but the seasonal cycle was different. The seasonal cycle reached a peak in about June or July. These vaults also showed a significant constant seepage term. One method of producing the observed pattern of seepage in these vaults would be to combine two seasonal cycles: one related to precipitation/evaporation and peaking in April; and one peaking in August and September and related to lawn watering. The sum of the two cycles would produce a third cycle with a maximum intermediate between the two (ie June or July) and a non-zero average seepage.

4.3.2 Chemistry

The second characteristic of sump seepage was the chemical composition of the water. Samples were collected from the cold sumps in vault chambers 713/189 and 713/190, the two that showed the most influence from non-precipitation related seepage. Therefore, these were the most valuable to obtain chemistry data from. Other sumps require heavy equipment to remove covers to access ports and were not sampled. Water samples were also collected from the raw water system and the potable

water system at CPP-699. Both raw and potable water are pumped from the Snake River Plain aquifer, and have essentially identical water chemistry. The water chemistry of the sumps was also similar suggesting a common, external source.

Simple mixing models were used to determine if sump water chemistry could be related to the mixing of precipitation or aquifer water with high-level liquid waste. Mixing ratios for different species were very different indicating that simple mixing could not explain the water chemistry. There was also insufficient chromium in the water for the cooling water to be the source.

Chloride and sulfate had similar concentrations in raw/potable water and in the sump water. These are relatively conservative species without a lot of sources or sinks in soil. This similarity suggests that water pumped from the aquifer was the source of water to the sumps. However, potable water, raw water, lawn watering, and fire water are all derived from the aquifer, and therefore have similar chemistry. Some species showed different concentrations than in the aquifer. Differences can be explained by dissolution of calcite from the soil, ion exchange of calcium for sodium, and leaching of nitrate and potassium added to the lawn in back of CPP-699 as fertilizer.

4.3.3 Volume and Proximity

The locations of pipelines carrying water from the aquifer were identified. There are potable water lines, raw water lines, and fire water lines all running near the east end of the tank farm. Maps showing the locations of these line in the vicinity of the tank farm are shown in Appendix A.

The volume of water entering the tank farm from different sources was evaluated. Based on the regression equations, an estimated annual contribution from precipitation was calculated to be 12,170 gal per year, or 41% of the total. The estimated contribution from the constant source was calculated to be 13,950 gal per year or 47% of the total. The remaining 12%, or 3,560 gal per year is from miscellaneous sources.

Volumes of water that could be released from all of the sources were evaluated. Many of the sources can only release a few to a few hundred gallons. Therefore, these sources cannot be a major contributor to seepage. However, many of these small sources (such as leaky steam valves, leaks from valve seals in waste transfer lines) do contribute to seepage periodically. The volume of water available from precipitation, after adjusting for evaporation, is 104,700 gal per year. The estimated volume of water available from lawn watering is 540,000 gal per year.

Pathways for water to enter the vault were also evaluated. There is a network of screened observation wells completed at the interface between the surficial sediments and the underlying basalt. This is at a depth of about 50 ft below land surface. The vaults are constructed on basalt, and so this is also the depth to the bottom of the vaults. The screened observation wells have been monitored for water periodically since 1972. The wells are dry essentially all of the time. In spring during very wet years, such as 1993, water has been detected in some of the wells. Excavations into the surficial sediment and drilling to the top of basalt for sampling projects have not encountered water-saturated soils. Therefore, no saturated perched water table exists at the sediment-basalt interface. Without saturated conditions existing outside vaults, there is no driving force to move water through the walls of the vaults. Therefore, seepage through the walls cannot be the pathway into the vaults.

In November of 1973, vault 713/190 was entered to investigate the source of water seeping into the vault. The report of that entry indicates that water was dripping down through the joints between the

ceiling beams and panels. Therefore, ponding on top of the vault and seeping through the roof has been observed as an actual pathway for water to enter the vaults.

An additional pathway into the vaults is along the encasements for the waste transfer lines and the drain lines from the monitoring stations to the vaults. The line from the tank farm to the New Waste Calciner Facility passes directly beneath the lawn west of CPP-699. The line to the old Waste Calciner Facility passes under fire water lines and a large drainage ditch along the southeast side of the tank farm. This pathway has not been confirmed, and would require investigation of the directions of flow and connections among the encasements, monitoring stations, and vaults.

4.4 Conclusions

Based on the analysis of seepage into tank farm vaults, the two most important sources of seepage are infiltration of precipitation and watering the lawn to the west of CPP-699. Infiltration of precipitation is a source of seepage to every vault except 781, which showed no seepage during the study period. The volume of water falling on the tank farm as precipitation is more than enough to provide the necessary volume of water. The most likely pathway for this water to enter the vaults is seepage through the membrane at some of the many perforations made for pipes, risers, and valve boxes. Once on top of the vault, this water can seep through joints in the roof. Approximately 41% of the water seeping into the vaults is from this source.

The second most important source of seepage for the tank farm is the watering of the lawn to the west of CPP-699. While the volume of water from this source is slightly larger than that from precipitation (47%) it only affects one vault. The pathway for water used on the lawn to enter the vault is not clear. For water from the lawn to get on top of the vault roof, it would have to move laterally some 30 to 40 ft with only 3 to 4 ft of vertical movement. This implies a very impermeable layer in the subsurface on which a perched water zone forms. Another possible pathway is along the pipe encasements and drain lines.

FIGURE 4.1
HILLW TANK FARM DIAGRAM
 WINCOPCHED WATER SUPPORT/MD

Goldier Associates

FIGURE 4.3
AVERAGE ANNUAL VOLUME OF WATER
JETTED FROM VAULTS BETWEEN
JUNE 1990 AND APRIL 1993
 WINCOPERCHED WATER SUPPORT/ID

Golder Associates

FIGURE 4.4
**SOURCES OF WATER THAT COULD CONTRIBUTE TO VAULT
 SEEPAGE AND PATHWAYS WATER COULD TAKE INTO THE VAULT**
 WINCOPERCHED WATER SUPPORT/ID

Golder Associates

Golder Associates

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Golder Associates

FIGURE 4.8
**CUMULATIVE SEEPAGE INTO VAULT SUMPS
 FOR SUMPS WITH HIGH SEEPAGE RATES**
 WINCO/PERCHED WATER SUPPORT/D

Golder Associates

PROJECT NO. 933-1150 DRAWING NO. 47101 DATE 12/17/93 DRAWN BY TB

5. CONCLUSIONS OF THE INVESTIGATION

The water inventory study has provided a much better understanding of water sources and releases at ICPP. The plant inventory equation has been greatly improved by upgrading metering systems on the water supply wells and waste disposal systems. Previously unquantified water releases have been estimated, and will be included in the plant water balance. This will provide more accurate reporting of water use at the facility to the INEL Nonradioactive Waste Management Information System. Plant water supply and liquid-waste collection systems have been evaluated for leaks, and release rates quantified for the northern portion of the plant. The sources of water seeping into vaults at the HLLW tank farm have been identified and quantified.

Three sources of water serving as recharge to the northwestern perched water body at ICPP were quantified. The three sources are: leaking pipes, irrigation of lawns, and natural recharge. Leaking pipes and natural recharge were found to be about equal in importance, with about 4 million gal/yr contributed to the deep perched water from each of the two sources. Irrigation of lawns contributes about 1.6 million gal/yr of recharge. Leaks identified during this investigation have been fixed or are in the process of being fixed. These repairs will significantly decrease the amount of water recharging the deep perched water. One source of water that was not evaluated was the periodic rupture of pipes that has occurred at ICPP. This type of release will likely continue to occur periodically with repairs being made as the breaks occur or as leaks are detected.

Seepage into tank farm vaults can be attributed to two primary sources, infiltration of precipitation and irrigation of the lawn in back of CPP-699. Precipitation was found to contribute to seepage into almost all of the vaults. Irrigation was a source of seepage into vault 713, at the immediate eastern end of the tank farm. Almost half of tank farm seepage is attributed to lawn irrigation.

This investigation has provided valuable quantitative information to DOE-ID and WINCO plant managers to make decisions regarding plant system operation and design. A better analysis of the plant water balance and quantitative estimates of water leaking from pipes in comparison to other sources allow informed decisions about the advantages to be gained by periodic leak monitoring and implementing corrective actions.

Results from this investigation will be a key input used by risk managers for the INEL Federal Facility Agreement and Consent Order from the State of Idaho, EPA Region 10, and DOE-ID in making decisions concerning the need for remedial action at ICPP. The decision to take remedial action will be based on the risk posed to human health and the environment. This decision will be made following the process outlined in the INEL Federal Facility Agreement and Consent Order.

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APPENDIX A.

Maps of ICPP Water and Waste Piping Systems

FIGURE A-4
DEMINERALIZED WATER PIPING
IN THE AREA OF INTEREST
EG&G/ICPP PERCHED WATER SUPPORT/ID

Golder Associates

FIGURE A-8
SANITARY SEWER WATER PIPING
IN THE AREA OF INTEREST
 EG&G/ICPP PERCHED WATER SUPPORT/ID

Golder Associates

FIGURE **A-9**
LANDSCAPE WATER DISTRIBUTION
EG&G/ICPP PERCHED WATER SUPPORT/ID

Golder Associates

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January 1994

**ICPP WATER INVENTORY STUDY
PROJECT SUMMARY REPORT**

B. T. Richards

IDAHO NATIONAL ENGINEERING LABORATORY

Managed by the U.S. Department of Energy

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