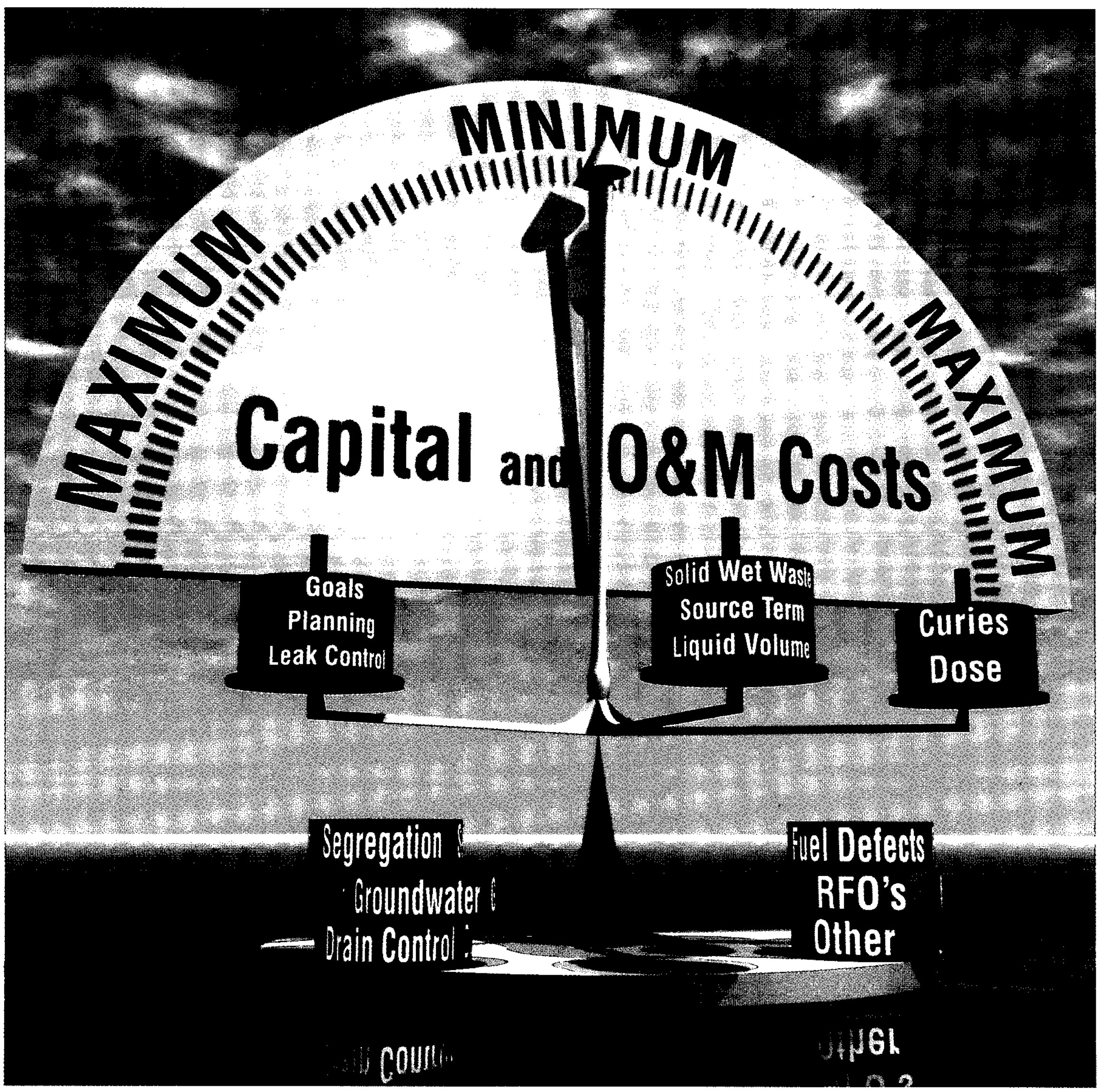
Radioactive Liquid Processing Guidelines

EPRI

Prepared by
The Radioactive Liquid Processing Guidelines Committee



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Radioactive Liquid Processing Guidelines

TR-107976

Final Report, September 1997

Prepared by
The Radioactive Liquid Processing Guidelines Committee

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REPORT SUMMARY

This report presents guidance for utility liquid radwaste processing program managers. The document is a summation of utility and vendor processing experience, and is intended for use as a tool to enhance liquid radwaste processing programs. Utilization of this information will result in optimized system performance, and a reduction in waste volumes and program costs.

Background
Historically, utility liquid processing programs have incorporated the use of original plant design processing systems augmented or replaced by vendor processing technology. More recently, utilities have responded to the challenge of cost reduction by re-evaluating existing liquid radwaste programs and available alternatives, targeting process efficiency enhancements and reducing associated program expenditures. In support of these efforts, EPRI undertook a project to assist the utilities in improving the cost effectiveness of their liquid radwaste processing programs and simultaneously enhance program performance.

Objective
To identify liquid radwaste process technologies, methodologies, recommendations, and experiences to optimize liquid processing programs.

Approach
A team of utility liquid processing professionals, EPRI, and technical consultants identified factors impacting liquid radwaste processing performance, volumes, and costs. The team also evaluated techniques and cost factors related to disposal of the resultant solid waste. The researchers performed an extensive review of past, present, and proposed processing technologies; their effectiveness and associated costs; and plant processing experiences and techniques. They also identified and incorporated the optimum process program components into this document. This report is a compilation of the analysis, and is intended to provide guidance to liquid radwaste processing program managers to enhance overall program performance.

Results
This document presents numerous guidance elements that managers can implement to improve processing program performance, and achieve significant cost reductions. The report includes an introduction and project overview; an executive summary describing the major components of a successful program; and specific program guidance. The guidance elements identify processing program components eligible for improvement;

and give specific guidance for improvement. The document also describes expected results of successful implementation. Many of the guidance elements have the potential to result in tangible cost savings for utilities.

EPRI Perspective

As utilities continually strive to maintain their positions in a competitive market place, modifications which result in improved processing efficiency and reduced operating expenditures will become more critical. Utilities can reduce the costs associated with radioactive liquid processing through improved program management without large capital expenditure. This report offers processing performance improvement and cost reduction oriented program enhancements based on actual plant experience and available technology.

TR-107976

Interest Category

Low level radioactive waste management
Radiation protection technology

Key Words

Radioactive liquid processing
Radioactive liquid waste management
Radioactive waste program cost reduction

ABSTRACT

Historically, utility liquid processing programs have incorporated the use of original plant design processing systems augmented or replaced by vendor processing technology. In the past decade, a seemingly endless influx of revisions to industry regulations and market driven options related to power generation, distribution and radioactive waste disposal, have resulted in a need for utilities to become even more cost efficient. Utilities have responded to this challenge by re-evaluating existing liquid radwaste programs and available alternatives, targeting process efficiency enhancements and reductions in associated program expenditures.

In response to this concern, EPRI undertook a project to assist the utilities in their efforts to improve the cost effectiveness of their liquid radwaste processing program and simultaneously enhance program performance. The project included a detailed analysis of utility and vendor process experience, technology, methodologies, and lessons learned. A report was then compiled that identified specific guidance targeting program cost reductions and process performance improvements.

ACKNOWLEDGMENTS

This report includes the work of many individuals who dedicated a great deal of time and effort to ensure the success of this project. Radwaste and Chemistry professionals from the following utilities and organizations contributed to the identification and evaluation of the guidance provided in this report. (listed in alphabetical order)

Baltimore Gas and Electric Company

CENTEC XXI

Commonwealth Edison Company

Duke Power Company

Duquesne Light Company

Entergy Operations, Incorporated

Houston Lighting and Power Company

Iowa Electric Light and Power Company

New York Power Authority

Northern States Power Company

Pacific Gas and Electric Company

PECo Energy Company

Pennsylvania Power and Light Company

Southern Nuclear Operating Company

TU Electric

Union Electric Company

Wisconsin Public Service Corporation

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Section 1 Introduction

1.1 Project Overview

In response to recent revisions to industry regulations and available options related to power wheeling and radioactive waste disposal, EPRI undertook a project to assist utilities in their efforts to enhance the performance and cost effectiveness of their liquid radwaste processing program. The project included a detailed analysis of utility and vendor process experience, technology, methodology, and lessons learned. A document was then compiled that identified specific guidance targeting process performance improvements and program cost reductions.

This report is a summation of that analysis. The user of this report is provided with specific issues and guidance.

1.2 Report Objectives

This report has several objectives. The overall objective is to provide guidance for attainable improvements that can enhance a processing program's performance. Benefits associated with the recommendations include reduced processing program costs, reduced waste volumes, minimization of environmental impact, and in some instances, reduced labor requirements.

The specific objectives of this document are to provide:

- A tool to manage and measure the success of a liquid processing program.
- Effective cost benefit and derived value analysis support.
- A compilation of the most effective liquid processing techniques and methodologies based on lessons learned from actual industry experience.
- Assistance with processing problem resolution.
- Techniques to develop increased station awareness through targeted information packages.

When implementing any of the recommendations or experiences included in this document, the program manager should ensure the improvement is thoroughly analyzed. This analysis should verify that the targeted goal matches the expected benefit to be derived, and that the improvement is expected to be—and remains—cost effective. Additionally, the utility should carefully evaluate the system/component performance prior to, during, and following implementation to ensure it is optimal and to provide data for future improvements.

1.3 Report Organization

Section 1 provides an overview and objectives of this report. Section 2 presents an executive summary containing a document synopsis as well as the most critical attributes and goals of a model liquid processing program. Section 3 provides program management guidance. Sections 4 through 7 contain detailed discussion related to program elements, additional guidance for successful liquid waste program management, and specific recommendations for use by utility radwaste program managers. Appendices A through D present applicable reference documents, a specific improvement index applicable to this report, example data tracking and trending concepts, and processing system selection examples.

1.4 Recommended Report Use

When utilizing the industry experience and guidance included in this document, the program manager should ***ensure any proposed changes are thoroughly analyzed. The evaluation should verify:***

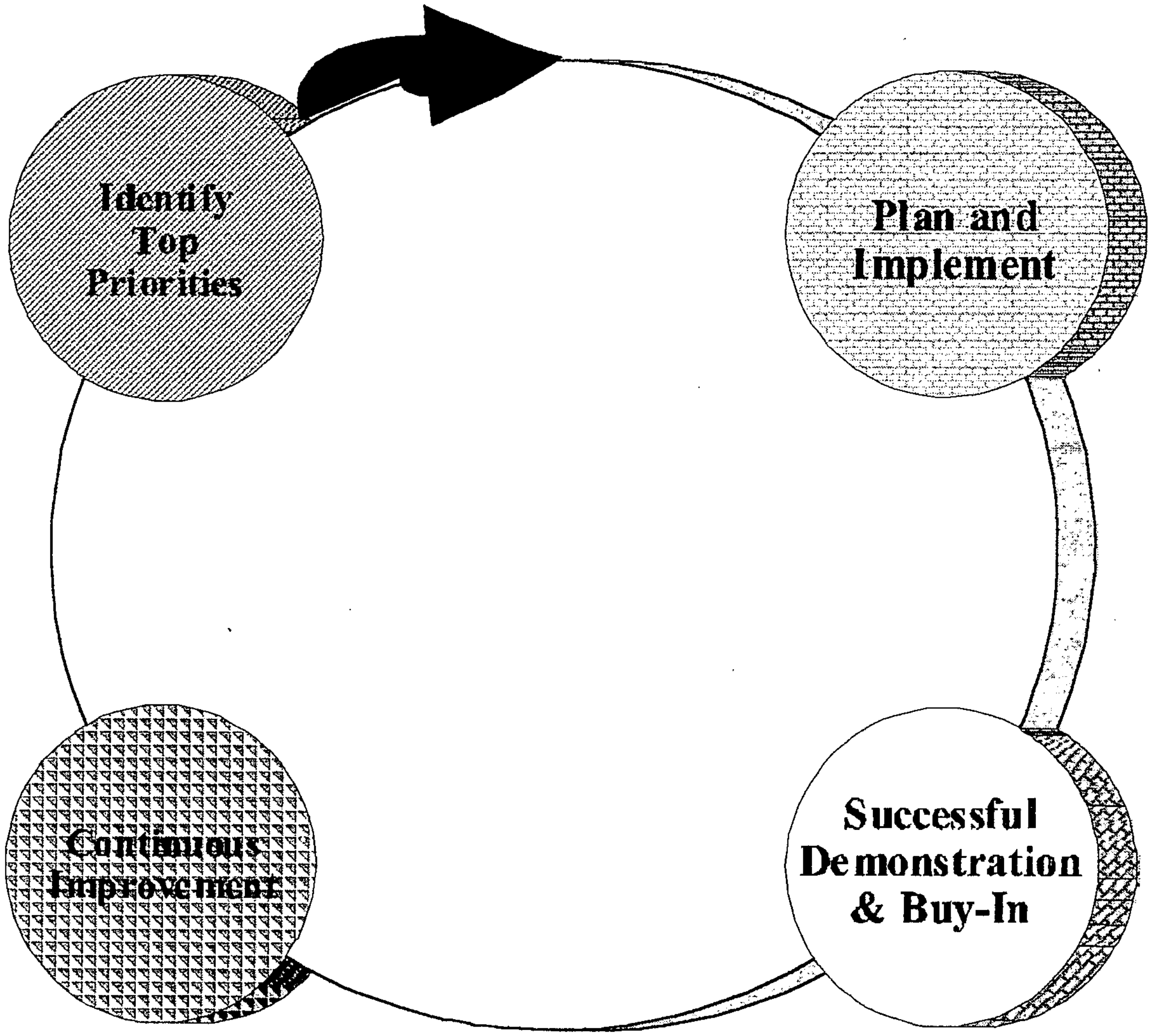
- ***Compliance with regulations and Licensing documents.***
- ***Cost effectiveness.***
- ***Process applicability (correct application for that technology).***

The utility should also carefully evaluate all factors associated with a technology or processing methodology prior to selection and implementation. When analyzing cost effectiveness, the manager should ensure the utility's goals and long range plans for liquid processing and waste disposal are known, and incorporated into the analysis. It is also imperative that the user of this report has a thorough understanding of available in-plant liquid and waste processing systems.

It is equally important to review the guidance with positive intentions, focusing on potential, rather than creating obstacles that prevent implementation and improvement. Many stations have successfully developed and/or implemented the processing guidance contained in this document. Your station can share that success through implementation of appropriate improvements.

After carefully reviewing this report, it is recommended that the station identify its top priorities and associated goals. Resources should then be focused on implementation of targeted improvements. Following successful demonstration of those changes, a continuous improvement plan should be followed that incorporates other applicable, prioritized program enhancements.

Figure 1-1 Improvement Implementation



Much of the guidance provided in this document directly impacts, or is directly impacted by, other station organizations. To ensure successful and continuous program improvement, those organizations should be involved in proposed changes to the program from inception of planning and implementation efforts. This will help to establish "buy-in", and hence support, from those organizations required for continued program success.

It is equally important to carefully assess the time for improvement implementation, relative to the projected cost benefit. Delays related to planning and execution of improvements will diminish the overall savings achieved.

NOTE: The words "routine" and "routinely" are used throughout this document to define frequencies or typical occurrences. This document is not intended to define individual "norms", but rather to establish the realization that routines are required to effectively manage the program. The time definition associated with routines will vary from station to station and by application in this report. It typically means weekly or less, prior to or immediately following a change in status, or when deemed necessary to successfully support the guidance provided. Its broad definition is meant to establish a **practice** of performing that guidance to further enhance program success and support for plant goals.

Section 2 Executive Summary

"Our experience at Comanche Peak clearly demonstrates that similar to an ALARA program, strong visible management support of our Liquid Processing Program is critical for achieving optimum plant staff participation. Without that support, liquid processing program performance remains a departmental issue. With it, the performance becomes a site priority."

Lance Terry
Group Vice President of Nuclear Production
Comanche Peak Steam Electric Station

2.1 Background

Historically, utility liquid processing programs have incorporated the use of original plant design processing systems augmented or replaced by vendor processing technology. In the past decade, a seemingly endless influx of revisions to industry regulations and available options related to power generation, distribution and radioactive waste processing and disposal, have resulted in a need for utilities to become even more cost efficient. In many cases, radwaste processing and disposal costs can be a significant portion of the overall station Operation and Maintenance (O&M) budget.

As a result of these issues, radwaste program managers are challenged by the need to provide a necessary service to the station in compliance with stringent regulations, while simultaneously reducing O&M costs. They have responded to this challenge by re-evaluating existing liquid radwaste (LRW) programs and available alternatives, targeting process efficiency enhancements and reductions in associated program expenditures.

In support of this effort, EPRI undertook a project to assist utilities with improvements to processing programs. The project targeted program cost effectiveness while simultaneously optimizing process performance. It included a detailed review of utility and vendor process experience, technology, methodologies, and industry lessons learned. This guidance document is a product of that project. It identifies specific program cost reduction and process performance enhancements.

2.2 Successful Program Management

Industry experience has repeatedly confirmed that the leading LRW processing programs achieve success only with the support of senior station management. The most successful liquid processing program managers are diligent in obtaining and maintaining site support of radwaste goals. This task can be complicated by perceived conflicts between processing and other established, well understood goals.

Liquid waste processing programs do not normally impact capacity factor or plant reliability. Therefore, processing issues may be assigned a less than ideal priority relative to the cost benefit associated with their resolution. A liquid radwaste processing program can have a significant impact on station O&M costs. While annual liquid radwaste processing program costs can easily range from one-to-several million dollars, the associated fixed labor costs are typically less than 50% of that amount. As a result, program enhancements in this area can result in significant, tangible savings to the utility. Also, improvements to liquid processing programs often impact programs and resources external to the lead processing organization. Therefore, those improvements need to be carefully assessed to ensure cost savings realized by those organizations are captured. This process can take several years to fully implement the enhancement, identify all cost elements, and realize quantifiable savings. The station should consider this time frame when assessing the cost benefit of an improvement.

Further complicating management of liquid radwaste processing programs is the "invisible" nature of the process. Liquid radwaste is generated and routed to treatment processes that are not normally accessed by the balance of the plant staff. This creates an artificial barrier between the person generating the liquid and the end result – processing media impact, solid waste generation and its subsequent disposal. This in-turn produces a challenging environment for program managers to effectively communicate the impact of liquid waste improvements to external organizations. The Radwaste organization possesses the technical expertise and equipment to process waste liquid once generated, but cannot control all inputs generated by external site organizations. Clearly defined **station** expectations that are effectively communicated by senior station management to the plant staff, will help the station achieve the desired Radwaste program goals.

2.3 "The Best" Program Attributes

The definition of a "successful" program varies between utilities. Regulatory compliance is the primary goal for all utilities and is a **non-negotiable component** of a successful program. The following table represents the elements or goals associated with an ideal liquid processing program. These attributes were derived from actual plant experiences related to successes and lessons learned from failures.

It is critical that a station's program performance be carefully measured using all, or combinations of, the following successful liquid processing program attributes:

Program Element	**Benefit**
♦ Comprehensive system performance monitoring program. ♦ Comprehensive outage water management. ◊ Radwaste involvement in pre-planning and execution. ◊ Integrated, formalized water management schedule. ♦ Accurate accounting of total liquid and solid wet program costs. ◊ Media procurement. ◊ Multi-discipline labor. ◊ Site-wide, impacted O&M costs. ◊ Disposal. ♦ Positive control of liquid process system(s) influent. ◊ Volume reduction (aggressive leak reduction, publicized goals). ◊ Quality of waste inputs. ♦ Active Chemistry involvement. ◊ Routine chemical characterization of process. ◊ Decision making input. ◊ On-going communication. ♦ Radionuclide source term reduction. ♦ Commitment of justified capital expenditures to attain significant program improvement. ♦ Adequate resources to evaluate emerging, cost effective technologies. ♦ Liquid processing program continuous improvement. ◊ Active, aggressive task force. ◊ Benchmarking. ♦ Aggressive materiel condition improvement for systems impacting liquid radwaste processing. ◊ Fix-It-Now Team. ◊ Priority based on impact.	♦ Positive position with industry organizations (NRC, ANI, INPO, EPRI, NEI, state and local regulatory agencies). ♦ Reduced outage duration. ♦ Low program O&M costs. ♦ Minimal environmental impact. ◊ Off-site dose. ◊ Activity. ◊ Chemistry. ♦ Minimized solid radioactive waste generation. ♦ Optimization of labor support requirements. ♦ A continually improving liquid processing program. ♦ Reduced curies. ◊ Released. ◊ Personnel exposure. ◊ Disposed.

Historically, the industry has used effluent activity and/or solid waste disposed as the principle performance indicators. These indicators are important, however, they are not the sole elements of a successful program. Their sole use can result in an under appreciation of the impact of other indicators (elements) associated with a cost effective program.

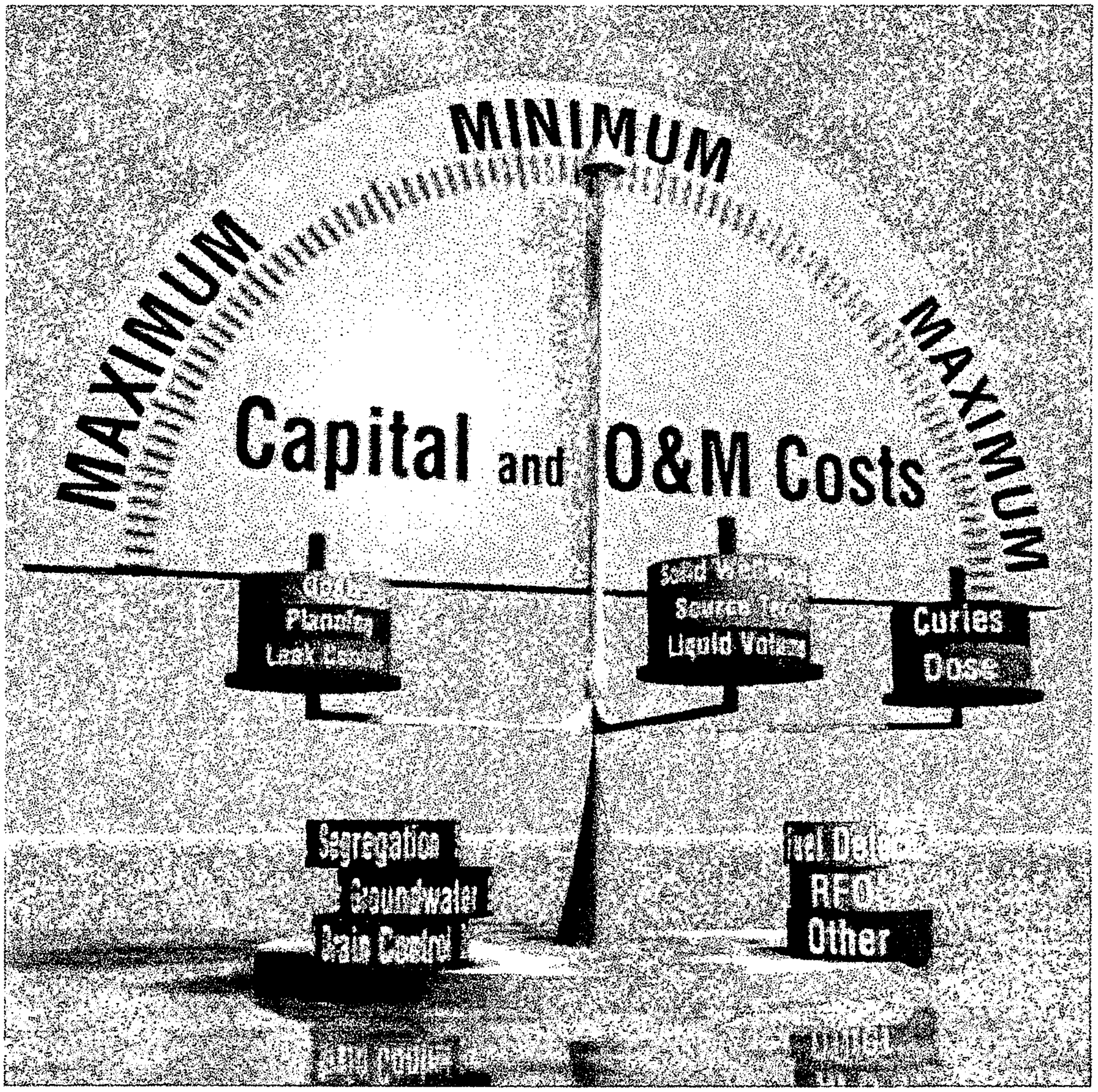
> **EXAMPLE**: At one station, Maintenance related system draining frequently resulted in routing of undesirable waste streams to the liquid radwaste processing system. This resulted in a reduced media life, increased waste disposal costs, exposure and labor requirements. An inter-departmental team analyzed draining practices and identified improvements. That plan resulted in media procurement savings for the Chemistry department and reduced personnel exposure. The Operations organization realized reduced demands related to media transfer, maintenance support planning, and equipment isolation and draining. The Radwaste organization significantly reduced solid waste packaging, transportation and disposal costs.

2.4 Program Direction and Focus

The program attributes presented above, while individually important, are confusing when combined and create conflicts when evaluating liquid waste processing strategies. For example, reducing processing system effluent activity may require more on-site exposure related to processing and packaging, and may increase program costs. Similarly, processing low quality liquid waste streams for recycle in an effort to reduce the effluent release volume to as low as is reasonably achievable, could significantly increase program costs, solid radwaste volumes, and on-site worker exposure, and can eliminate needed processing flexibility.

The following figure illustrates the issues station management needs to carefully weigh and balance to achieve program success.

Figure 2-1 Balancing the Elements of a Successful Program



For those programs that are successful, senior management's level of effort is significant in that it provides focus and direction related to the desired program endpoint. Middle and low level managers need to be presented educated, clear **and achievable** direction related to benchmarking and program expectations.

Section 3 Program Management

3.1 Overview

Successful management of a liquid processing program encompasses an array of responsibilities and also requires knowledge of numerous program elements. Support is required from site organizations external to the processing program manager as well as from other industry organizations. The site staff must be educated on aspects of the program that affect them and conversely, that they can impact. Program costs and performance need to be closely monitored to ensure process performance is optimal and the program is cost effective. Self assessments combined with industry agency evaluations/inspections should be used to benchmark program performance and also to assist in developing improvement plans.

This section provides guidance on key management elements of a liquid processing program. It is intended to serve as the foundation for successful management of a process program.

3.2 Program Element: Goals

3.2.1 Program Impact

Goals and objectives provide challenge, focus, and overall direction for any organization. Radwaste goals are often relegated to a less visible status when compared to other primary station goals such as those related to capacity factor or the as low as reasonably achievable (ALARA) concept. How goals are communicated to or perceived by the plant staff directly impacts the station's ability to meet those goals. Achieving goals is directly influenced by visible management support, it should be ***present and apparent*** to the plant staff.

The goals, while individually important, are confusing when combined, and create conflicts when evaluating liquid waste processing strategies. For example, reducing processing system effluent activity may require more on-site exposure related to processing and packaging, and may increase program costs. Similarly, processing low quality liquid waste streams for recycle in an effort to reduce the effluent release volume to as low as is reasonably achievable, could significantly increase program costs, solid radwaste volumes, and on-site worker exposure, and can adversely impact processing flexibility.

The Radwaste organization possesses the technical expertise and equipment to process waste liquid once generated, but cannot control all inputs generated by external site organizations. Clearly defined goals will help them achieve the desired endpoint.

3.2.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Establish **station** goals associated with liquid waste processing that are related to effluent activity and liquid waste generation volumes. In addition to these goals, a station typically should have goals associated with:

    - Program cost.
    - Processing media throughput in gallons processed per cu. ft. of media.
    - Solid waste generation resulting from processing radioactive liquids for recycle or release.
    - On-site worker exposure.
    - Off-site exposure.

2. Communicate goals in a language the entire site staff can understand (e.g., create a goal the people that impact that goal can visualize). Goals are established to test the mettle of the staff, not to generate reports.

3. Develop a **station** liquid generation goal in gallons per day (gpd) for LRW. The goal should be shared by those departments responsible for liquid waste generation.

NOTE: The Radwaste organization possesses the technical expertise and equipment to process waste liquid once generated, but cannot control all inputs generated by external site organizations. Clearly defined goals will help them achieve the desired endpoint.

> **EXAMPLE:** Can the staff comprehend the impact of a 0.7 gallon per minute (gpm) leak? The use of gpd versus gpm will result in a more dramatic and meaningful portrait for the plant staff and help to focus the appropriate amount of attention on the leak rate. A 0.7 gpm leak rate equals a TOTAL leak rate of ~1,000 gpd. The plant staff that reviews and uses the data would probably be more concerned about a source of leakage that produced over 1,000 gallons of liquid every day than they might be for a leak that produces only 0.7 gpm.

4. Ensure that goals related to **station** performance be recognized as tools for monitoring station performance relative to waste generation, rather than as Radwaste organization proficiency indicators.

5. Develop goals that do not conflict with each other. A zero release plant cannot achieve a goal of zero process media solid waste generation. Similarly, achieving zero release will increase program costs and site exposure.

6. Communicate the goal to the plant staff and increasing the staff's awareness relative to the costs associated with LRW processing, packaging, and spent media processing and disposal. Focus initial educational efforts on the organizations that have the largest impact on the LRW volumes. As a minimum, these should include all operations and maintenance personnel.

3.2.3 Cross Reference(s):

1. An industry paper titled "Liquid Radwaste Minimization Where we were, where we are, where we are going".

3.3 Program Element: Tracking, Trending & Reporting

3.3.1 Program Impact

Tracking, trending, and continually evaluating program performance can provide valuable information to station management. The data can be used for:

- Ensuring compliance with regulatory requirements.
- Monitoring a processing system's or a single component's performance relative to established goals.
- Planning and implementing LRW processing improvements.
- Program cost analysis.

- Problem identification.
- Abnormal leak rate identification and analysis.
- Modification evaluation.

Most utilities track and trend portions of the pertinent program data, such as liquid waste generation and resultant solid waste volume. However much of the readily available chemistry and processing data is typically not fully utilized (i.e., individual processing systems and component's decontamination factors (DF) are not tracked on a routine basis). At the more successful stations, the existing data review process allows for a timely, detailed system performance evaluation, and subsequent processing configuration adjustments.

Tracking, trending, and evaluating processing data allows a continuous and consistent program analysis to be performed, thereby ensuring that the systems are used in the most efficient manner possible. The benefits of tracking and trending include:

- Lower system effluent activity or dose.
- Better use of processing media.
- Timely correction of system deficiencies.
- Generation of less liquid and solid radwaste.
- Timely and correct feedback to station personnel.
- Reduced O&M expenditures.

3.3.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Establish a formal plan to routinely analyze, track, and trend the LRW system performance. Some of the key areas to evaluate include:

    - Sources of liquid waste.
    - Individual system and/or component's influent and effluent chemistry and activity characteristics.
    - System performance (i.e., DF, gallons per ft^3 of media, etc.).
    - Costs for all aspects of liquid processing.
    - Liquid waste processing generated solid waste volumes.
    - Performance relative to established station goals and the industry as a whole (i.e., activity, dose).

2. Track and trend data that can be used to supplement and more easily verify station progress and station improvements. This data is useful during reviews by various regulators and can provide additional information for the required annual reports (i.e., environmental and effluent discharge). Trending these

data may also help to validate that the plant is being operated within its design basis.

> **EXAMPLE:** Radwaste sump runtime data was reviewed to verify that observed leakage from a Safety Injection valve was within the leakage assumed in the design calculation of the radiological consequences of leakage into the building during a design basis loss of coolant accident (LOCA).

3. As a minimum, establish a routine review of process parameters. It should include personnel such as the chemistry radwaste program expert, radwaste operator and/or supervisor, and radwaste system manager.

3.3.3 Cross Reference(s):

None

3.4 Program Element: Benchmarking and Self Assessment

3.4.1 Program Impact

Evaluating a liquid processing program and comparing the program performance to other stations can be a useful exercise. Numerous industry organizations such as EPRI, ANI, INPO, NRC, and NEI provide data for program performance evaluation relative to other stations, as well as for assessment of vendor performance. Additionally, they provide forums for communications regarding industry concerns and the status of technological advances. In numerous cases these discussions lead to specific program problem resolution, and/or spawn new ideas that result in technological advances for the processing industry.

The information can be obtained in several different ways including the following:

- Assessments and evaluations performed by the organization.
- Periodic industry organization reports.
- Meeting attendance.
- Newsletters.
- Vendor processing performance reports.
- Electronic mail.

Caution should be exercised when evaluating the data provided. Plant data surveys typically rely on individual interpretation of the data request format. As such, data related to volumes generated, processed, packaged, shipped, disposed, or stored may be misinterpreted as a result of plant specific definitions, processing systems in use, vendor data, units, reporting periods, etc. The result may cause inaccurate and unrealistic expectations related to perceived plant performance when compared to other stations.

Another and similarly effective method of benchmarking program performance is by direct contact with industry peers. This provides an opportunity to obtain current data, discuss data anomalies, and potentially share solutions to specific program problems.

In conjunction with benchmarking, critical self assessments are an especially useful tool for ensuring optimal program performance and for verification of compliance with station and industry organization's expectations and regulations. Internal Quality Assurance audits performed using a proceduralized checklist can provide performance trending data for comparison to previous performance. Self assessments are also an excellent method of soliciting feedback from the balance of plant staff related to the impact of the process program and proposed changes.

3.4.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. When using data provided by industry organizations for program comparison or evaluation, it is extremely important to ensure the data was collated, analyzed and presented in equitable terms. The benchmark data should be clarified to account for differences in liquid processes used such as demineralizers, membrane, steam generator blowdown(SGBD) and condensate polishing. Verify generated, released and disposed data are segregated for accurate volume comparisons. In other words, be sure you are comparing apples to apples.

2. Obtain accurate plant data via direct contact with peers at stations with similar processing configurations and inputs. A list of well thought out questions can produce accurate data for comparison or evaluation.

3. Performance of self assessments on a scheduled, periodic frequency. It is important that the assessor have a fundamental understanding of the process methodology and technology. Typically, the more knowledgeable the assessor, the more beneficial the assessment. However, it is equally important that the assessor not be directly associated with the processing program thereby potentially biasing the assessment results.

4. Solicit feedback from plant organizations impacted by the liquid processing program, specific liquid processing support organizations and senior plant management. Review and analysis of honest feedback can often be an enlightening experience resulting in changes that create improved "buy-in" and support from organizations external to the liquid processing program.

3.4.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI product "waste***WORKS:***Wet Computer Code".
2. The EPRI document titled "Cost-Effective Liquid Processing Programs".

3.5 Program Element: Ownership & Empowerment

3.5.1 Program Impact

Teams and task forces can achieve impressive results and are an excellent communication forum, but require controls and diligent oversight to ensure parallel tasks are not negatively impacted. Liquid radwaste processing is a multi-disciplined program and requires **commitment** from other station organizations. Teams have proven to be very effective for implementing major changes such as advanced equipment installation, or improving liquid processing system influent quality. They can produce a "Win-Win" situation by resolving issues related to one organization, such as Operations or Chemistry, while simultaneously improving radwaste processing program performance.

Several utilities have successfully used the team concept for resolution of issues ranging from repair of minor equipment deficiencies to complex radwaste process technique or equipment modifications. The results have been achieved as a result of communication definition, communication effort minimization, and productivity maximization.

EXAMPLE: At one utility the Component Cooling Water by original design was drained to the radwaste system. Since this system contains a corrosion inhibitor which prematurely exhausts the demineralizers, a practice of verifying that no radioactivity is present before draining to a non radioactive sump was established. Unfortunately this necessitated draining via two 1 inch lines and was a very lengthy process. With the desire to shorten outage duration, Operations wanted to return to the original design. A team of two (Chemistry & Operations) came up with a compromise that allowed the system to be drained quickly and yet still be drained to the non radioactive sump.

3.5.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Establish a processing improvement team.

2. The goals of the team should be clearly defined as soon as possible.

3. Schedule meetings in advance and in consideration of participant's collateral responsibilities.

4. The roles and responsibilities of team members should be defined to all team/task force members. A team leader/mediator with overall responsibility is a must!

5. Tie-in targeted improvements to organization's goals. Successfully achieving challenging goals related to housekeeping or leak reduction, can result in improvements to the liquid radwaste processing program.

6. Team involvement should require minimal paperwork. Minimize administrative demands on team members and the team leader.

7. Focus on action items, prioritization, solutions and schedules.

3.5.3 Cross Reference(s):

None

3.6 Program Element: Cost Analysis

3.6.1 Program Impact

Processing cost analyses can be useful when evaluating the significance of a waste stream, the current costs when comparing alternative processing strategies, as well as the impact of waste generation on the station's O&M budget (i.e., when attempting to heighten station awareness relative to liquid waste minimization). The calculated data can also be used for justifying repairs and/or equipment replacement. There are numerous cost elements to be considered in the analysis including the following:

- Processing system operational labor (loaded rates including benefits).
- Processing media.
- New media handling, and warehousing.
- Spent media changeout/transfers.
- Waste volume reduction (VR).
- Waste packaging.
- Disposal and/or storage.
- Annualized system upgrade costs.
- Program management.
- Processing configurations and alternatives.
- Equipment repairs and preventative maintenance (PM).

3.6.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

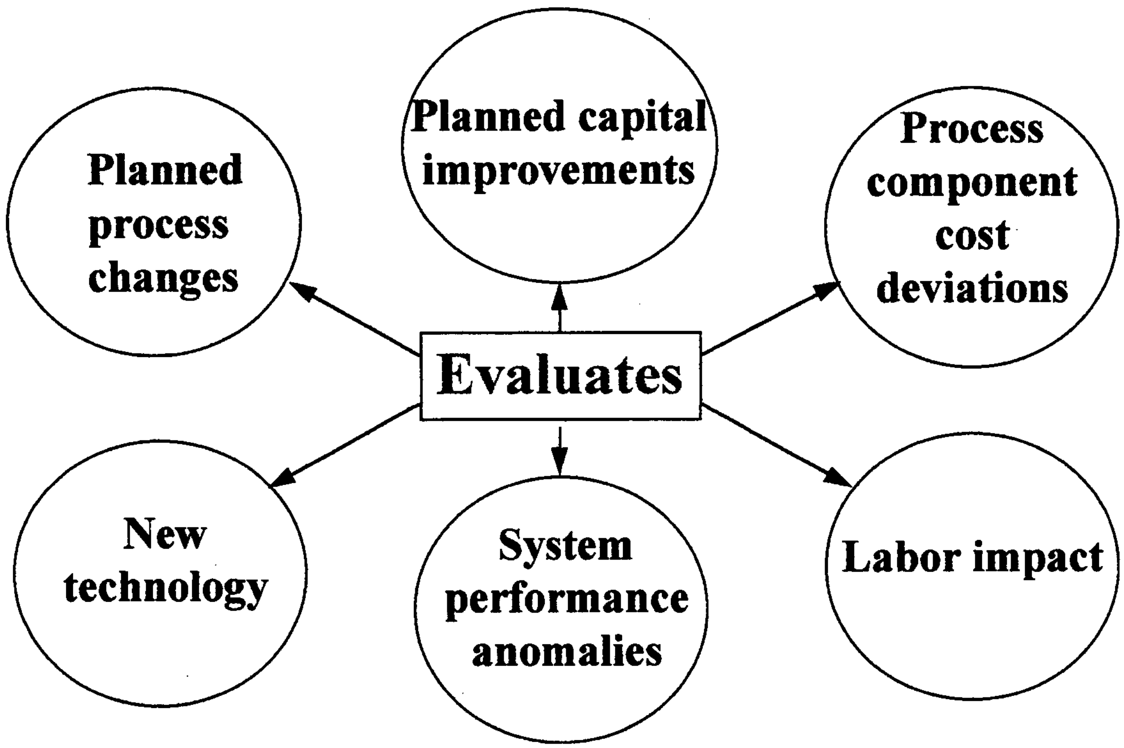
> **CAUTION:** An individual station's processing cost-per-gallon typically accounts for varying combinations of program elements such as labor, media, packaging, shipping, disposal, etc. Therefore it is recommended that both fixed and variable cost elements be clearly defined prior to benchmarking station cost performance.

1. Calculate program costs on a routine basis or whenever program cost elements are known or expected to change. A useful calculation unit is cost-per-gallon for all liquid waste processing. This cost unit is especially useful when educating the balance of the plant staff on LRW minimization issues.

2. Use the EPRI waste*WORKS:*Wet code for developing a detailed, site specific cost database and for evaluation of proposed or implemented changes.

3. Perform a total cost analysis routinely or when any cost factor changes. That value should then be compared to the program cost-per-gallon.

Figure 3-1 waste*WORKS*:Wet



3.6.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI product "waste*WORKS:*Wet Computer Code".
3. The EPRI document titled "Cost-Effective Liquid Processing Programs".

3.7 Program Element: Station Awareness

3.7.1 Program Impact

The communication of a liquid processing program's status to the plant staff is important. It can increase their awareness relative to the costs associated with radwaste generation, processing, packaging, and disposition. Several methods for increasing station awareness include senior management communiqués, training, posters and written and verbal program updates.

For most processing issues, there are two levels of required knowledge, management and the balance of plant staff. Everybody in management has a personal computer on their desk! The use of computer related mail and network services has rapidly gained acceptance as a means of official communications throughout the industry.

Many utilities use internal networks to communicate budget status, daily newsletters, site-wide meeting schedules, enforcement actions, and numerous other items of general interest.

> **NOTE:** The use of computer based communication networks offers a unique opportunity to develop and transmit radwaste performance data and issues to all station management, particularly to those that directly impact program performance. It typically allows the user to transmit written and graphic communiqués, and more importantly permits instant, documented feedback!

For the balance of plant staff, posters can be an effective form of communication. It is important not to overwhelm workers with posters for every "important" issue in the station. Strategic wording and poster placement can help to ensure that the posters will result in the desired message being conveyed to the staff. They are also an excellent medium for communicating through the use of photographs, computer generated graphics or artwork, not only what is good, but also to illustrate an unacceptable radwaste condition or status.

3.7.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. The use of verbal or written communications can effectively communicate program goals, status and issues. Initial educational efforts should be focused on the organizations that have the largest impact on the LRW volumes. These organizations typically include operations, planning and maintenance.

2. Several stations have developed detailed chemistry performance tracking programs that can be accessed by non-chemistry station personnel for information only. This is an excellent technique for disseminating information related to radwaste chemistry data.

3. Design a basic liquid processing information bulletin for distribution by electronic mail or remote broadcast monitor. When designing the routine

communication or plant accessible data program, consider the following guidelines.

- Access and use the plan of the day or daily newsletter to transmit general interest or unique items to the entire plant staff. This will help to maintain a "radwaste presence". Several utilities use monitors mounted in key areas of the plant to broadcast closed loop communications that are modified daily. Including radwaste topics of interest in this type of communication significantly increases the audience size and profile.

- Define the target audience and develop a master template for data input and transmission. This will reduce the routine workload.

- Query the recipients and based on feedback, revise the template as appropriate to accommodate the end user. Remember the goal is to educate the recipient, not yourself.

- When developing a radwaste database for information access by non-radwaste personnel, ensure headings, units and data are clearly understood by users other than the database development team. Misunderstood information is often more harmful than no information.

- For routinely issued communications, only provide the necessary information - don't transmit an entire database. It is very easy to collate data from various tracking programs and transmit too much data. It probably won't all be read, and may generate a lot of unnecessary queries requiring responses.

- Electronic mail systems should not be relied on to educate or update the general plant staff, realizing that a large percentage of the plant staff do not have routine access to computer terminals.

4. Develop a few posters that clearly illustrate the targeted issue (in the correct audience "language"). The posters should have clear, concise messages with a minimum of background clutter. ***Locate posters where they are not in conflict with other messages such as those for security and fire protection.*** It is important to ensure the location doesn't compromise the ALARA concept or worker safety (i.e., in stairwells or near doors).

5. Develop Operator aides for controlling processing system liquid inputs and system/component drain path selection.

3.7.3 Cross Reference(s):

None

3.8 Program Element: Training

3.8.1 Program Impact

Radwaste related training is an excellent and relatively inexpensive vehicle for improving program performance. It can often be accomplished in conjunction with training required for continued plant operation. The use of general access or radiation safety training is fine for generic topics, but typically workers are inundated with information during those sessions, and the effectiveness of including important radwaste issues may be compromised.

In an effort to continually improve plant processes, workers are given significant amounts of training related to job specific performance and numerous other issues important to successful plant operation. However, these training session do not normally provide for routine refresher training related to radioactive waste processing. This limits the ability of a Radwaste organization to improve their overall program. Additionally, by default, this can result in the plant staff assuming that radwaste processing is not an important or costly aspect of plant operations.

3.8.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Provide radwaste task specific training to the radwaste/liquid processing staff. As part of that training, include an information "hotline" phone number and key waste issues.

2. Ensure the training clearly defines responsibilities as well as how individual performance impacts program success.

3. Provide the training on a routine basis and most importantly, ***prior to*** process changes in the plant (i.e., prior to outages).

4. Update lesson plans frequently to ensure the classroom information exchange is accurate and timely. Include outage impact as part of that update and exchange.

5. The most successful programs include the actual processing system operators and chemistry personnel in the development of training curriculums.

6. Include a brief radwaste processing topic in each of the trade specific training programs. This can be established as an integral part of routine training, or can be effectively presented as a stand-alone presentation by Radwaste management. Several utilities have successfully developed 15 minute to 1 hour radwaste training modules for inclusion with routinely scheduled trade specific training. The use of upbeat videos is used at several utilities as a successful means of communication without increasing the instructor workload, and they can be designed and used for a broad spectrum of audiences. A brief radwaste specific module to be given to a mechanic in conjunction with a pump rebuild class, is relatively easy to develop and can result in large dividends for the radwaste organization.

7. Incorporate articles related to radwaste program successes or lessons learned from failures, as a routine feature in daily, weekly and monthly newsletters.

3.8.3 Cross Reference(s):

None

3.9 Program Element: Planning

3.9.1 Program Impact

At the majority of stations, liquid waste generation and disposition guidelines, controls, and procedures related to system draining and/or maintenance evolutions are not included in the work planning process. The most successful programs have found that the use of proceduralized water management controls and guidelines has resulted in cost effective and optimum waste liquid treatment. Equally important planning considerations are related to major projects such as chemical system/component cleaning, chemical decontamination and major component replacement.

3.9.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Develop work planning controls and procedures that account for liquid waste generation and water management. Require radwaste/operations involvement in routine/daily evolutions and in the preplanning process to ensure generated volumes are managed and processed in the most cost effective manner.

   Items to consider as part of the planning program should include the following:

- Radwaste notification.
- Projected volume.
- Source and quality of liquid.
- Alternatives to processing.
- Best drain point, draining equipment (i.e. flanges, hoses, fittings, etc.), drain path, and collection tank.
- Optimum treatment method.
- Impact on parallel processing operations.
- Impact on effluent activity.

2. Involve radwaste personnel in the early stages of major project planning. In addition to the elements discussed above, the following issues should be adequately addressed to ensure continued program success.

    - Impact of specialty solutions and chemicals on processing equipment or media.
    - Available waste treatment and VR options.
    - Final waste form and disposal considerations (i.e., chelants).
    - Impact of liquid system component change on system chemistry. Issues to consider include aggressive chemical species, increased particulate activity resulting from system disturbance, biogas generation, and increased liquid waste volumes as a result of system draining and/or pre-use replaced component testing.

3. As part of the planning process, coordinate work evolutions with media end-of-life (i.e., internal system maintenance or spent fuel pool (SFP) work with end of filter and/or demineralizer run).

3.9.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI product "waste*WORKS:*Wet Computer Code".
3. The EPRI document titled "Cost-Effective Liquid Processing Programs".

3.10 Program Element: Equipment and Materiel Condition

3.10.1 Program Impact

Radwaste equipment and materiel condition can significantly impact radwaste process options and in some instances balance of plant operations. A successful program in this area can result in a reduction in liquid and solid waste generation, and optimum effluent quality for recycle or release. In order to effectively monitor and assess the performance of processing systems, the basic process stream parameters must be known by the system operators. Inoperative equipment does not allow process operators to continuously monitor process parameters and to make adjustments to processing operations as necessary.

The use of dedicated radwaste processing operators typically results in improved performance, consistent process results, and the development of "system experts".

However, in this capacity, operators may be required to operate equipment that is not fully functional. This has the potential to present a negative message communicating management approval—that this mode of operation is acceptable for radwaste operations and will therefore be acceptable for balance of plant operations.

3.10.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Establish a LRW task force with efforts focused on equipment performance, identifying deficiencies, and implementing solutions. Several stations have successfully accomplished this through the use of High Impact Teams (HIT).

2. Similarly, many stations have established a Fix It Now (FIN) Team which also is responsible for immediate resolution of equipment deficiencies.

3. If equipment repairs are not feasible, consider replacement of the equipment with technologically advanced equipment. This would give operators the necessary and improved tools to perform liquid processing in a more efficient and cost effective manner.

4. Assignment of work/repair request priority commensurate with the impact the deficiency has on processing results and costs. The radwaste program manager should be included in the process.

5. The radwaste (RW) manager should be aware of LRW deficiencies and provide the necessary motivation to achieve their resolution.

3.10.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Cost-Effective Liquid Processing Programs".
3. The U.S. Department of Energy (DOE) document titled "Guidelines for Mixed Waste Minimization".

4. The EPRI document titled "Radwaste Desk Reference Volume 4: Mixed Waste".
5. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
6. An industry document titled "Reactor Water Cleanup Systems, a Comprehensive Summary of Design, Corrective Actions and Improvements".
7. A U.S. Nuclear Regulatory Commission Regulatory Guide titled "Maintenance of Water Quality in Boiling Water Reactors".

3.11 Program Element: Exposure Control

3.11.1 Program Impact

One of the primary reasons for processing radioactive liquids is to remove the radioactivity. In all currently used techniques, the activity is concentrated in a solid media or a liquid waste slurry. The net effect is that personnel exposure is associated with system operation, maintenance, testing, and waste packaging and disposal. The exposure sources are varied and dependent on process type, system configuration, plant installation, remote technology use, shielding and liquid process volumes.

Exposure resulting from liquid processing evolutions should be routinely evaluated to identify process or equipment changes that can result in reduced exposure to station personnel. An equally important benefit is reduced station exposure and an improved ALARA rating with industry agencies.

3.11.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Routinely evaluate liquid processing exposure and sources. Consider the impact of the following:

    - Equipment reliability and activity buildup.
    - Technology currently in use versus cost for replacement.
    - Functionality of media in use and reuse of media in other applications.
    - Media changeout criteria.

2. Evaluate the use of evaporators carefully. Consider the exposure associated with operations, maintenance and waste packaging. Carefully evaluate retiring the evaporator and replacing it with alternate advanced technology.

3. Filter changeout criteria should be evaluated to ensure filter use is optimized.

> **EXAMPLE:** "Clean" filter differential pressure (dP) profiles should be established and not exceeded. Precoat, non precoat and minimum precoat filter/demineralizers are particularly susceptible to irreversible fouling that can result in elevated dose rates and increased personnel exposure.

4. Verify that exposures associated with spent filter handling are minimized through the use of remote tooling and grippers and shielded portable transfer containers. Evaluate packaging practices to ensure package efficiency is maximized and personnel exposure is minimized.

> **EXAMPLE**: At several stations, computer assisted design (CAD) systems have been successfully used to develop optimum loading plans for high exposure solid wastes. This tool can be effectively used to optimize loading strategies, minimizing costly void space and personnel exposure.

5. Demineralizer use and transfer techniques should include analysis of the following:

    - Vessel shielding and personnel access controls.
        - Sky shine from demineralizer vessel.
    - Vessel internal design.
        - Rinse and retention element type and sizing.
    - Transfer line flush capabilities.
    - Use of remote valve and sample manifolds versus interchangeable flexible hoses requiring local manipulation in the demineralizer vicinity.

6. Utilize automated remote resin samplers to ensure representative samples are obtained with minimal personnel exposure.

7. Perform filter sampling only as required using remote grippers or hole saw.

8. Desludge/clean sumps, tanks, and filter/demineralizer vessels on a routine basis to remove potential sources. The use of robotics has recently gained popularity as the associated technology and capabilities have improved.

   The key is to perform this evolution on a routine basis, precluding the development of significant solids in an undesirable form. An additional benefit of this process is reduced solids carryover into the process stream and probable improvements in process performance and improved effluent quality.

3.11.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
4. The EPRI document titled "Proceedings; Second Workshop on Condensate Polishing with Powdered Resin".
5. An industry document titled "Reactor Water Cleanup Systems, a Comprehensive Summary of Design, Corrective Actions and Improvements".
6. A U.S. Nuclear Regulatory Commission Regulatory Guide titled "Maintenance of Water Quality in Boiling Water Reactors".
7. An industry paper titled "An Overall Crud Reduction Program for Deep Bed Polishers in BWR Nuclear Plants".
8. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".
9. The EPRI document titled "Low Level Waste Characterization Guidelines".

Section 4 Liquid Waste Influent Volume Minimization

4.1 Overview

Liquid waste processing influent volumes are often impacted and/or controlled by station organizations external to the processing program. A concerted effort by multiple plant organizations is required to successfully reduce liquid process volumes. Reducing the sources of liquid waste benefits a station in numerous ways, including the following:

- Lowers the volume of liquid waste requiring processing, increasing the options available for cost-effective treatment.
  - Creates time to evaluate processing options.
- Enhances control over influent water quality.
- Lowers processing costs—all liquid waste processing activities, regardless of method, have a cost per gallon associated with them.
- Minimizes the environmental impact.
- Decreases the volume of solid radwaste requiring packaging and disposal.
- Reduces makeup water requirements.

Prior to implementation of the guidance in this section, the program manager should first review their plant practices, processes, and evolutions that generate LRW. The review should include expected LRW volumes and LRW drain systems.

4.2 Program Element: Influent Identification and Evaluation

4.2.1 Program Impact

Identifying inputs to the liquid processing system(s) is the first logical step in minimization of process volumes. Once the influent source and volume are identified, it can be evaluated to determine the best minimization method. Several techniques for identification incorporate the use of installed plant equipment such as sump run timers and tank level indicators. Others employ additional investigational methods such as performance of water balances on a cyclic basis, or chemistry analysis to fingerprint the source and determine its origin based on chemical or radioactive characteristics.

4.2.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Routinely identify all major sources that contribute to the liquid waste volume generated such as:

    - Direct influent to the sumps and tanks.
    - Sump inputs to tanks.
    - Valve and equipment internal and external leakage.
    - Process waste (i.e., resin cleaning, chemistry samples, on-line monitors, etc.).

> **NOTE:** It is important to initially limit the scope of this program to assure focused attention is given to the priority inputs, and that the plant staff sees an improvement in this area is achievable.

2. Evaluate whether the source(s) and volume generated are necessary for plant operation, or if the source(s) are the result of equipment/component leakage. As part of the evaluation, consider the following:

    - Do the source chemistry characteristics result in additional solid process waste being generated?

    - Is the leakage at the design flow-rate? Many plants have experienced increased flow rates with equipment seal and packing "wear-in" and have not readjusted the new seals to the minimum allowable specifications.

    - Is the design leak-off consistent with today's technology (i.e., live load mechanical seals and packing), or with the least achievable leak-off for that design?

    - Is the cost for processing currently installed seal package/packing leak-off volumes over the expected life of the plant, cost effective when compared to an improved seal package installation?

    - Are the conductivity, organic contamination, nutrient level and other physical characteristics affecting processing and/or can this information be used to help identify the source of the liquid.

    - Is an alternative method available for use that would minimize the generation of LRW (i.e., dust mop vs. wet mopping, recycle liquid from system draining back into the system vs. draining to radwaste)?

EXAMPLE: The process of hydrolancing generates two waste streams. The first is the lance stream itself. The second is the bypass flow from the high pressure pump which flows at 2 - 5 gpm whenever the high pressure lance is not being used. When using high pressure hydrolancing to clean component cooling water (CCW) heat exchanger tubes, one plant directs the organic laden waste and bypass flow directly into the service water outlet line of the CCW heat exchanger. This is accomplished using simple pumping systems and existing line taps. The advantage of redirecting this waste stream is reduced loading on the radwaste processing system.

3. Use installed equipment such as sump run timers, control room data loggers, or flow totalizers to determine the time and approximate volume of liquid pumped out of specific sumps. This data can aid in identification of planned plant evolutions or anomalies occurring during that time period. Once identified, the specific liquid waste generation evolution can be evaluated to determine the feasibility of influent minimization or elimination.

4. Use tank level indicators to perform a daily water balance for the waste system. Similar to sump run timers, the data can then be used when evaluate inputs for minimization or elimination.

5. Use of a chemistry analysis of sump contents on a routine basis can provide useful data. The knowledge of sump conductivity, pH and radioactivity can be very useful for tracing the origin of processing system inputs and when evaluate processing options. This data can be used to quickly identify "off normal" waste influents.

6. The use of historical data (or data from similar units at dual unit sites) related to volumes can be effective for identifying improvement opportunities.

7. Use a unit specific "drain tree" to assist in identification of unknown input identification.

EXAMPLE: At least one station routinely uses installed drain line clean-out trap access plugs to visually observe, measure and sample inputs of unknown origin.

4.2.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".

4.3 Program Element: Segregation

4.3.1 Program Impact

Segregation of liquid wastes prior to processing can be one of the most effective methods of reducing process volumes with minimal effort or cost. Creative analysis and use of installed plant piping, sumps and tanks can often result in the ability to effectively separate low-to-non radioactive liquid wastes for alternative release methods.

These wastes can sometimes be released without expensive treatment processes, requiring only minimal filtration and/or monitoring prior to release to ensure compliance with release criteria. Similarly, these wastes are also frequently low quality wastes that result in less than desirable process performance, can prematurely deplete processing media, and result in increased solid waste volumes. Processing this waste using alternate methods is typically more cost effective.

EXAMPLE: Several stations use partially depleted media or simple filtration for low quality waste processing. Typical all-inclusive costs associated with those processes are <$0.25 per gallon. A significant savings can be realized when a high technology processing system such as filter and demineralizer or membrane system costing $0.60 per gallon is not challenged by this waste stream. Using this scenario, alternate processing for 400,000 gallons annually would result in an annual cost savings of ~$140,000.

Another option frequently overlooked is recycling back to the system from which the liquid waste originated. This method of liquid disposition requires preplanning and may entail the use of special or dedicated drain and collection equipment.

EXAMPLE:	Several stations completely drain and rinse waste holding tanks prior to outages. That volume is used to collect reactor coolant system (RCS) draindown waste augmenting normal RCS holding tank capacity. After sample and purity confirmation, the "waste" liquid is recycled to the primary system.

4.3.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Evaluate all low activity and clean inputs to liquid process systems for alternate disposition options. As part of the evaluation consider the following:

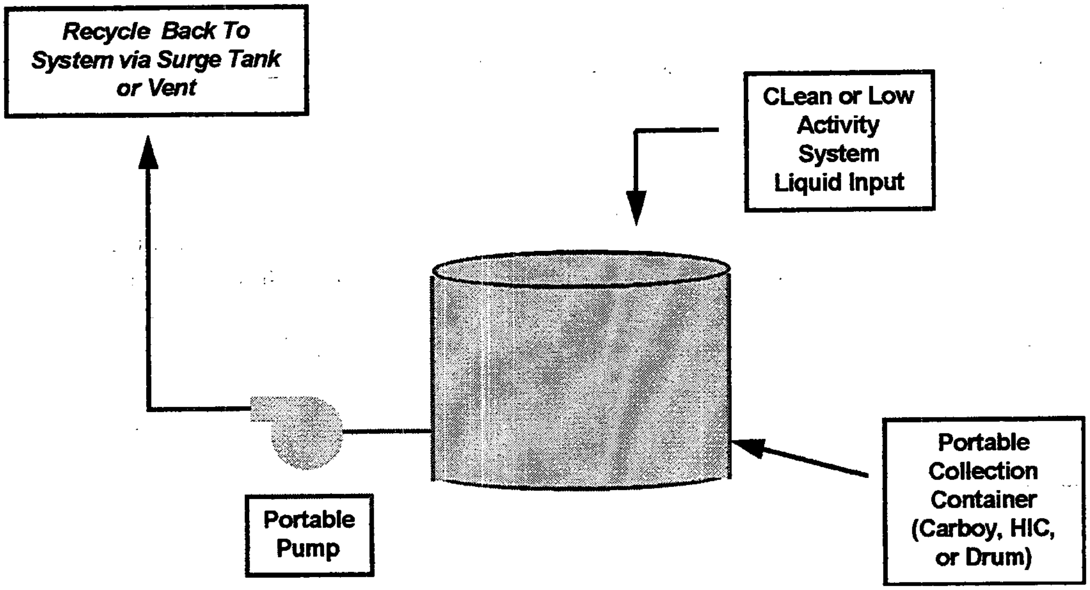
CAUTION:	The station should carefully review FSAR, Licensing documents and release permits prior to using process alternatives to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

- "Retired" components available for use such as pipe, pumps and tanks.
- Use of laundry and decontamination solution waste tanks for filtration and monitored release.

CAUTION:	The station should evaluate the impact of aerated water on the system to which the water is being recycled (e.g., closed cooling hydrazine corrosion control additive concentration).

- Drainage of systems to portable collection containers and recycle the liquid back into the system. Figure 4-1 contains a simplified diagram of one configuration for this process.

Figure 4-1 Typical Recycle Configuration



2. Establish a controlled tie in at the effluent of radwaste processing system equipment prior to release monitor tanks to permit input of liquid wastes acceptable for direct monitored release, thereby precluding unnecessary processing.

> **EXAMPLE:** At least one station has installed a clean waste header to divert "clean" wastes directly to tanks for release following monitoring. The header is non-safety related, is PVC and requires minimal installation engineering and labor effort. The header access ports are locked and controlled by a select group of station personnel.

4.3.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "Cost-Effective Liquid Processing Programs".
4. The U.S. DOE document titled "Guidelines for Mixed Waste Minimization".
5. The EPRI document titled "Radwaste Desk Reference Volume 4: Mixed Waste".

4.4 Program Element: Leak Repair & Prioritization

4.4.1 Program Impact

Leakage from plant equipment negatively impacts the processing program in several ways. Typically, leakage increases the liquid volume requiring processing, as well as adding nutrients and oils that cause biogassing. The rate of input from leaks is often not quantified on a routine basis, and therefore plans cannot be developed to optimize process performance. A secondary issue is the effect on contamination controls and personnel exposure. Leaks can result in increased area contamination, increased solid waste generation and potentially increased personnel exposure as a result of more stringent contaminated area entry requirements. Active leaks negatively affect the plant's materiel condition as well as the plant staff's perception of the effectiveness of the equipment maintenance program.

Leaks can also result in decreased processing performance through the introduction of undesirable chemical species to the processing system. Refer to Section 5 of this document for further discussion on the effects of influent quality on process performance.

4.4.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Develop and maintain an accurate list of existing plant leaks, including both clean and contaminated system leaks. The following techniques may enhance efforts to accurately identify leakage sources:

    - Visual observation - boroscope, remote video.
    - Portable temperature indicating/thermography devices.
    - Chemistry analysis of liquids.
    - Microbiological analysis of liquids.
    - Stethoscope/listening devices.
    - Use installed clean-out trap access plugs to visually identify, quantify and sample inputs of unknown origin.

2. Include a list of top priority leaks on the morning report or for discussion at operations oriented management meetings.

3. Revise the station procedure for leak prioritization so that a high priority is always given to leaks that generate LRW. Particular attention should be given to high activity and high conductivity wastes that more rapidly deplete processing media.

4. Establish a multi-phase leakage reduction goal, initially targeting those that have the most significant impact on processing operations, working towards a station goal of zero leakage to process systems. In an attempt to reduce outage duration, many utilities have recently increased the amount of on-line maintenance. This has created a need to develop challenging concepts for safe and efficient leak repair to assist in achieving this goal.

4.4.3 Cross Reference(s):

None

4.5 Program Element: Outage Success

4.5.1 Program Impact

The most common measurements for determining the success of an outage are the number of outage days, number of tasks completed, outage cost, and personnel exposure. However, the volume of outage liquid processed, its effluent quality, and the resultant solid waste volume are effective measuring tools of assessing the radwaste outage program. To aide in achieving success in these areas it is paramount that many of the concepts in this document be considered and implemented well in advance of planned outages.

Outages typically generate the largest acute volume of liquid waste from system draining, refueling, system chemistry adjustments, spent media changeouts and unit startup. Therefore, it follows that planning is the most critical element of successful outage liquid waste management - understanding in advance the projected waste sources and volumes can lead to successful waste segregation, processing and effluent recycling, or release. Outage specific goals clearly communicate objectives and typically improve "buy-in" from other organizations. The most successful sites integrate water management activities directly into outage schedules.

Even the most successful outages remain dynamic in nature, with unexpected issues driving changes to both schedule and scope. As such, a successful outage LRW plan requires flexibility and deviations in process strategies. The most important aspect of successful outage program management, is to ensure those lessons learned are accurately documented and are incorporated into future outage work plans.

The benefits of a detailed and integrated outage processing plan combined with specific outage processing goals include:

- Minimization of liquid waste requiring processing and discharge.

- Improved coordination between system draining requirements and start of maintenance activities.
- Better ALARA coordination between system draining and work activities. In some instances, primary system draining may be scheduled after completion of work in an area to minimize the dose rates in certain areas of the plant during maintenance activities.
- Minimization of microbiological growth nutrients in liquid waste requiring processing.
- Liquid generation rate is commensurate with treatment system capabilities.

Meeting the established goals creates a win-win situation for all parties involved.

4.5.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Aggressively pursue involvement in all phases of outage planning as early in the planning schedule as practical, beginning with the preliminary outage work list.

> **EXAMPLE:** Several plants integrate system draining and water movement needs into their refuel outage work schedule. One plant maintains a water plan for both primary and secondary systems. As a result, that station has been able to reduce floor drain influents by 60% by developing an integrated water plan during outages. During a recent outage, floor drain influent quantities were not significantly different than quantities seen during normal operations.

Examples of water plan entries are shown below:

PRIMARY WATER MOVEMENT PLAN RFO8

DATE & Ref. #	MODE	ACTIVITY	ACTION	COMMENTS
10/12* DNM30005	3	Borate RCS to >1800 ppm	Approx. 21,000 gal of 7000 ppm from BAST 'B' required. Divert RCS ~21,000 gal to RHUT 'B'	BAST "A" and RWST are operable boron sources.
10/12* DNM30030	3	CVCS/BTRS Flushes & Degas	Drain to RHUT 'B'	<5000 gal OTN-BG-00004
10/12*	5	Maintain BAST 'A' and the RWST operable.	**During 'A' train electrical outage, align 'B' boric acid transfer pump to 'A' BAST to maintain 'A' BAST operable.**	Volume in 'A' ~80% This is to maintain both the RWST and 'A' BAST operable. BAST "B" will be diluted to 2200 - 2400 ppm B for RFP cleanup system and refilling of the RWST.
10/12*	5	Adjust 'B' BAST to 2200 - 2400 ppm demin water.	Fill 'B' BAST to ~60% level with demin water. Recirc tank and sample. **TANK IS ISOLATED DUE TO 'A' TRAIN ELECTRICAL OUTAGE.**	This is in preparation for operation of the RFP cleanup system and RWST fill. Tank is approximately 2400 ppm.
	5	**Crew briefing prior to drain/refill**		**SOS 95-0872**
10/14* DNM50052	5	Drain RCS to a Pressurizer level of 20 - 25%	Send 10,600 gal to RHUT 'B'	RHUT 'B' is to be used for drain down of the RCS.
10/14* DNM50054	6	Drain RCS to 6" - 12" below flange	Drain 6,400 gal to RHUT 'B'	Drain Rx vessel to RHUT 'B' via letdown. Both fuel pool cleanup filters in service per final safety analysis report (FSAR) during refuel ops. OTN-BB-00002, RTN-HC-00500
10/14-10/15	5	Batch to 'A' BAST	Batch 5 batches to 'A' BAST to raise level to ~55%	'A' BAST remains operable, sample each batch tank to verify contents.
10/15 PWM001A	6	Adjust RHUT 'B' to 2200 - 2400 ppm B	Chemistry to sample Need ~50,000 gal of 2200 - 2400 ppm B for flood-up.	Required to support flood-up to 23' above flange. Level at 65% (34,000 gal) at 2257 ppm B. **Tag RHUT 'B' as 2400 ppm boron**

2. Establish outage specific goals related to liquid volume generated, solid waste generated and liquid effluent activity.

3. Work with system engineers, chemistry, operations and planners to determine the following information:

- Projected volumes from each task or evolution.
- Best drain path to segregate and optimize system performance.
- Ability to capture and recycle liquid versus process and release.
- Ability to monitor and release, without major processing.
- Alternate system isolation and draining or maintenance options that would result in decreased liquid waste volumes.
- Optimum outage task sequence to maximize use of filters, resins and other processing media.

CAUTION: Outages are dynamic in nature - established water management plans should be reviewed frequently (dependent on outage duration and scheduled work) and revised as necessary.

NOTE: Successful program managers constantly challenge established outage liquid waste management techniques in an effort to minimize outage liquid wastes, while simultaneously improving the quality of LRW generated. In order to improve, "the way we've always done it" should be challenged at every opportunity with the objective to create innovative outage liquid waste management concepts.

4. Perform pre-outage equipment preparations. This includes changing process media to accommodate local work or to support planned liquid waste processing. Additionally, holdup/retention tank liquid volumes should be minimized in anticipation of outage waste generation.

5. Capture and document innovative ideas and lessons learned from each outage as well as from other stations that have successfully planned and executed outages. Similarly, input from stations that have reduced outage duration should be incorporated into the liquid waste management program.

4.5.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

4.6 Program Element: Precipitation and Ground Water

4.6.1 Program Impact

As a result of the number, size and complexity of nuclear plant structures, many stations experience the intrusion of rain and ground water to LRW collection sumps and tanks. Additionally, several stations have installed moats or berms around tanks external to the plant. The tanks contain potentially contaminated liquids and therefore, the precipitation collected in these moats is often routed to the radwaste processing system.

The collected rain, ground and moat liquid is typically free from site specific contamination, but does contain microbes. If contained prior to commingling with other plant LRW it can ordinarily be released without processing. However, frequently the plant's structural complexity results in difficulty with this approach.

Therefore, the waste is often routed to radioactive sumps and waste tanks, requiring processing prior to release. In addition to increasing program costs associated with increased process volumes, these waste streams typically contain impurities (such as particulate organic matter), or can "flush" impurities form floor and equipment surfaces into the process system, negatively impacting process performance. A detailed discussion related to water quality impact is contained in Section 5 of this document.

4.6.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Minimize the volume of precipitation and ground water that requires processing by identifying and eliminating points of intrusion through the use of sealants.

2. Install temporary or permanent containments to collect the ground water around those sources that cannot be cost effectively repaired. The water should be sampled and monitored during release without processing. This can be accomplished as a stand alone evolution, or routed to the effluent of the processing system prior to release monitor tanks. Alternatively, the volume can be pumped to installed low quality liquid collection tanks such as laundry or decontamination waste tanks that are only filtered and monitored for release, bypassing other liquid processing components.

4.6.3 Cross Reference(s):

Appendix A - Reference(s):
1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

4.7 Program Element: LRW Resulting From Process Media Handling

4.7.1 Program Impact

> **NOTE:** Plant experience has consistently demonstrated that this waste stream is one of the most difficult to process.

Transferring and/or packaging new and spent processing media such as ion exchange material or carbon can generate large volumes of liquid waste requiring processing. Spent media vessel sluice or carbon vessel backwash volumes typically range from as low as 3,000 gallons to as high as 30,000 gallons per evolution. Often the empty media vessel requires additional rinsing to remove residual crud (the bathtub ring) minimizing the potential for immediate contamination of the new media charge. New media is then sluiced into the vessel and possibly rinsed prior to being placed in service, generating additional liquid waste.

Transferring waste media from storage tanks to the shipping package can result in significant volumes of package decant wastes. Additionally these wastes typically have high activity and solids content associated with them. This negatively impacts processing operations.

At some stations ultrasonic resin cleaning (URC) systems are used for condensate deep bed resin cleaning. URCs typically generate large volumes of waste water that require processing prior to recycle to a condensate storage tank (CST).

> **EXAMPLE:** A single URC typically generates between 15,000 and 30,000 gallons of waste liquid, with some stations generating > 45,000 gallons per URC. Using an average of 30,000 gallons per URC with one demineralizer cleaned per week, results in an annual waste system influent volume of ~1,560,000 gallons. At one station, the contracted LRW processing service is $0.15 per gallon. Processing their waste liquid produced during URC results in an annual processing cost of in excess of $234,000.

4.7.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Perform an analysis of media transfer operations to identify the optimum volume for media sluice, backwash, and rinse evolutions. The operations, radwaste and radiation protection personnel performing the task may be a valuable source of information when determining the reason for fluctuations in waste volumes for similar evolutions.

   The use of differential tank or sump volumes and/or the use of installed or portable flow instrumentation can provide valuable data for this analysis.

2. Establish a dedicated crew to perform media transfers. The crew should be provided with detailed training, chemistry support, and management support to optimize the process and minimize liquid waste generation.

3. Using the data obtained in recommendation 1 above, install procedural controls to provide concise guidance to operators and radiation protection personnel involved in media handling evolutions.

4. Using the data obtained in recommendation 1 above and the procedural controls in recommendation 2 above, install improved components and/or physical controls to minimize liquid inputs where appropriate. Examples include:

   - Installation of improved vessel sparging or rinse systems.
   - Use of flow rate meters and/or flow totalizers.
   - Installation of manual valve stops and pressure regulators to limit flow.
   - Elimination of crud traps that result in additional ALARA flushing.

5. Evaluate the volumes of liquid generated during URC by performing a detailed review of the operational aspects of the process.

6. Evaluate and implement the use of a more efficient process for cleaning secondary resins. An advanced resin cleaning system currently being used at two stations uses a vibrating screen system and a high pressure spray to clean the resin. The system typically generates 7,000 to 8,000 gallons per operation, generating significantly less liquid waste than currently available alternatives.

7. Contact other stations concerning their experience and incorporate lessons learned.

8. Collection of sluice water in separate tank or container for alternate processing.

9. Filtration of sluice water prior to entry into collection tank. Consider portable filters with down flow, inside to out flow cartridges or bags. They are designed for removing large quantities of fines in such waste liquids.

4.7.3 Cross Reference(s):

Appendix A - Reference(s):
1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI product "waste*WORKS:*Wet Computer Code".
4. The EPRI document titled "Cost-Effective Liquid Processing Programs".
5. The EPRI document titled "Liquid Waste Processing at Commanche Peak".
6. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

4.8 Program Element: Process Alternatives

4.8.1 Program Impact

Identifying and implementing the use of alternatives to processing liquid wastes is an often overlooked option to reducing generated waste volumes. In addition to decreasing waste, this option can also result in improved influent quality and improved process performance.

At almost all sites, a few other radioactively "clean" waste streams are routed to the liquid processing system as a result of original plant piping configurations, or in some cases, as a result of historical use of these process paths. The volume of liquid introduced under these circumstances is not always significant, and in many cases the actual influent volume is often not quantified. However, the combined effect of several "minor" inputs can be significant, increasing program costs and/or negatively impacting process performance.

Feasible alternatives to liquid waste processing should always be evaluated for implementation.

4.8.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

CAUTION 1: The station should carefully review final safety analysis reports (FSAR), Licensing documents and release permits prior to using process alternatives to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

CAUTION 2: For existing system modification or alternate use, a cleanliness flush should be performed prior to use, to minimize cross contamination of primary systems or components.

1. Identify alternatives to processing such as sample, monitor and release, while maintaining compliance with discharge permits relative to chemistry specifications, radioactivity and off-site dose criteria. ***The use of retired or infrequently used components and systems often provides viable alternatives with minimal capital expenditure.*** Examples of specific components to evaluate include decontamination solution tanks, laundry drain tanks and evaporator effluent retention tanks.

2. Install permanent or temporary berms to retain and segregate clean liquids for collection and monitored release.

3. Evaluate the use of semi-portable tank or bladder and pumping skids for collection and routing of clean liquid wastes. The liquid can be pumped directly to release monitor tanks or to other plant components precluding the need for normal processing.

4. Install permanent fittings at drain and vent points to facilitate temporary connections to alternate disposition paths.

4.8.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".

4.9 Program Element: Sampling Waste

4.9.1 Program Impact

At many stations waste from sample panels and in-line monitors are routed to LRW processing systems. Isolating liquid sample streams between samples, can result in inaccurate sample analysis due to inadequate purge, and/or sample line residuals being introduced into the collected sample. Some sample streams require continuous flow to supply in-line chemistry monitoring instrumentation.

The use of continuous flow and discharge chemistry laboratory demineralized water units can generate significant quantities of liquid waste requiring processing. The liquid, while chemically and radioactively clean can still result in increased program costs as a result of process labor and/or cost-per-gallon process contracts.

The combined sample input rate from all sources can ***easily exceed*** 3 gpm or 1,500,000 gallons annually. This volume is often significantly higher in BWR stations.

4.9.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Evaluate alternative routing for all sample waste. Options include re-routing to condenser hotwells, radioactively clean sumps, and tanks for filtration and release. Laboratory volumes can often be emptied to carboys for alternate processing and release. It is important to ensure proposed changes are in compliance with regulatory guidance, station operating procedures and Licensing documents.

2. Modify, or placing mechanical stops for throttling the flow from all sample taps to the minimum allowable, while maintaining the proper flow for accurate chemical analysis. Consider installation of "spring" valves for demineralized water taps.

3. Evaluate the processing system input from primary sample systems. Ensure the flows are established at the minimum required for accurate sample analysis.

4. Install recycling or closed loop units for chemistry laboratory demineralized water needs.

4.9.3 Cross Reference(s):

None

4.10 Program Element: Miscellaneous Secondary System Waste

4.10.1 Program Impact

Secondary liquid waste inputs originate during system/component draining and venting, or from leakage. The most common sources of secondary waste are Closed Cooling, Service Water, HVAC, Fire Protection and Chill Water systems. Frequently, the volumes generated are significant, and are generated on a routine basis during system performance verification or PMs. Additionally, these waste streams are typically low quality, negatively impacting processing operations. They can contain significant levels of nutrients that support microbial biogassing.

> **CAUTION:** Several of the following considerations involve reconfiguring systems, or alternate uses of existing systems. The station should carefully review FSARs, Licensing documents and release permits prior to implementing this guidance to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

4.10.2 Guidance - Closed Cooling

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Establish water management plans based on required maintenance or performance testing to optimize treatment and/or disposition practices.

2. Perform an analysis using corrosion inhibitor addition logs and makeup water addition rates, to identify system leakage. Warehouse issuance of corrosion inhibitor may be misleading as that typically includes all stock issued, but not necessarily added to the system to date.

3. Collect and recycle as much of the generated volume as practical. The cooling water should be sampled and its reuse approved by the chemistry organization.

4.10.3 Guidance - Service Water

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Establish drain paths for releasing the waste water without processing. The liquid should be sampled and/or monitored during release to ensure compliance with plant requirements.

> **EXAMPLE:** At least one station makes use of the negative pressure created by service water pumps to vacuum drag water from the header isolated for work, to the header currently in service. This allows rapid water movement and no secondary waste is created.

4.10.4 Guidance - HVAC Condensation

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Contain all HVAC condensation and route/pump it to clean monitored systems or release monitor tanks, bypassing normal LRW processing.

> **EXAMPLE:** As a result of humid conditions, one station experienced very high generation volumes from this source. They installed steel drip trays and hard piping to route all condensation to a clean waste header eliminating a significant cost per gallon processed.

4.10.5 Guidance - Fire Protection

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Evaluate periodic system flush requirements versus benefit derived. Consider reducing the flush time to an acceptable minimum, thereby reducing LRW generation.

2. Use component specific fittings and hoses to route flush water to clean monitored system headers or release monitor tanks, bypassing normal LRW processing.

4.10.6 Guidance - Chill Water

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Similar to closed cooling system waste, establish water management plans based on required maintenance or performance testing to optimize treatment and/or disposition practices.

2. Collect and recycle as much of the generated volume as practical. The cooling water should be sampled and its reuse approved by the chemistry organization.

4.10.7 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Cost-Effective Liquid Processing Programs".
2. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

Section 5 Improving Influent Waste Stream Quality

5.1 Overview

Improving the quality of liquids to be processed can significantly reduce the volume of waste solids and process media wastes requiring disposal. This can also result in a higher quality processing system effluent for release or recycle. Additionally, influent quality improvements can enhance the performance of, and extend run times for, processing system media and/or components.

The combined potential effects of influent waste stream impurities are:

- Unnecessary sludge generation.
- Additional processing media use.
- Generation of biogas in wet solid waste containers.
- Additional liquid handling and processing.
- Reduction in the quality of processing system effluent.

Prior to implementation of the guidance in this section, the program manager should first review plant practices, processes, and evolutions that generate LRW. The review should include expected LRW quality and LRW drain systems.

5.2 Program Element: Chemical Control

5.2.1 Program Impact

At most stations, the chemical control programs are designed to prevent contamination of primary surfaces with detrimental chemicals. Additionally, the majority of stations have expanded their program to incorporate controls to minimize or eliminate the generation of mixed wastes. ***The most successful programs also evaluate the impact chemical use and disposition has on liquid processing programs.*** Some stations have further expanded their chemical control programs to minimize the inputs of materials that stimulate biogassing of solid radwaste.

5.2.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Ensure the station chemical control procedure includes a required evaluation and controls for chemicals relative to their impact on processing system operation (and potential mixed waste generation). Chemical permits should include a clearly defined liquid waste system impact evaluation as a component of the approval process.

2. Ensure approved chemicals remain the "best" available to successfully complete the assigned task without the use of chelating agents.

3. Evaluate the process requiring chemical use versus the derived benefit. Frequently, housekeeping processes can be performed without the use of chemicals (i.e., routine damp mopping with water can be substituted for less frequent aggressive cleaning with detergents).

> **EXAMPLE:** At one station, floor wax (and therefore wax strippers) was used to minimize contamination buildup and improve station appearance. Floor wax, acrylic floor sealers and strippers will prematurely deplete or coat LRW processing resins and blind filter media. The potential personnel exposure saved through contamination reduction, as well as the aesthetic benefit of glossy floors, did not off-set the potential personnel exposure attributed to sluicing and packaging spent LRW processing media. The process was discontinued.

4. Eliminate the use of undesirable chemical/solvents in the radiologically controlled area (RCA) through product or process substitution. Product users (i.e., maintenance, chemistry, operations) should be included in product substitution efforts. This will increase "buy-in" and help to ensure a

satisfactory product is obtained, by giving them the proper tools to perform required tasks. Products currently used that would negatively impact processing operations should be prohibited from the RCA.

5. Purge the warehouse stock of all inventory of chemicals not permitted for use in the revised chemical control program. Such chemicals should include those that contain chemical species that are capable of promoting microbial biogassing. This should include chemicals used primarily in the non-RCA as well. A comprehensive stock purge will assist in ensuring undesirable chemicals aren't used in the RCA, and will reduce associated warehouse inventory taxes.

> **EXAMPLE:** One station has successfully controlled chemicals through the use of a Chemical Use Review Board (CURB). This small, inter-discipline committee meets briefly (<20 minutes) each week to review presentations on new chemical's proposed for use. The committee then establishes adequate controls for approved chemicals in accordance with established procedures. The effort expended is minimal but has a significant impact on the success of their program.

6. Provide alternative materials that are compatible with processing media in both full strength and diluted forms.

7. Provide clearly identified containers and direction for collection of residual chemical wastes in designated locations. It is equally important to minimize frequent relocation of the containers, thereby minimizing worker confusion. Label all containers being used even on a temporary basis.

8. Revise training programs to incorporate specific training related to chemical controls.

5.2.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The U.S. DOE document titled "Guidelines for Mixed Waste Minimization".
3. The EPRI document titled "Radwaste Desk Reference Volume 4: Mixed Waste".
4. An industry paper titled "Mixed Waste Prevention Through Chemical Control Programs, Chemical Use Review Board"
5. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

5.3 Program Element: System Draining & Drain Control

5.3.1 Program Impact

The majority of stations have elements of a formalized water management program. Liquid waste generation and disposition guidelines, controls, and procedures related to system draining and/or equipment repairs are included in successful work planning processes.

Use of proceduralized/integrated water management controls and guidelines can result in improved influent quality and optimum treatment.

Floor drains are potentially the source of numerous undesirable inputs to the radwaste system. At many utilities controlled area drains are not labeled to control inputs—the station instead relies primarily on training and worker awareness to control floor drain inputs. Contracted and new employees are inundated with a great deal of information during access training. As a result of this, the probability of floor drain use restrictions being retained by workers, and subsequently program success, is diminished. Labels can clearly communicate restrictions related to use of individual drains.

> **EXAMPLE:** At least two utilities have experienced complete demineralizer system break-through due to single incidences of small quantities of unauthorized chemical intrusion via the floor drains. The resultant media replacement and disposal costs were in excess of $75,000 per incident.

Additionally, much of the solid radioactive sludge generated is directly attributable to floor drain inputs. As a result of normal foot traffic, maintenance evolutions, and plant operations, a great deal of unwanted debris such as dirt, paint chips, and other granular materials is introduced to sumps, hold-up tanks, and processing systems. This waste, once exposed to liquid and higher activity materials, is both difficult and expensive to remove, package, and dispose. Floor drain sludges have been found to be a significant source of the biogassing microorganisms that can produce problems in solid wet waste containers.

5.3.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Develop work planning controls and procedures that account for liquid waste generation and water management. Include radwaste/operations involvement in the preplanning process to ensure generated volumes are managed and processed in the most cost effective manner. Items to consider as part of the planning program should include the following:

    - Radwaste involvement.
    - Accurate identification of the liquid volume.
    - Source and quality of liquid.
    - Analysis of alternatives to processing.
    - Selection of best drain point, draining equipment (i.e. flanges, hoses, fittings, etc.), drain path, clearly identified drains and collection tank.
    - Suggestion of an optimum treatment method.
    - Liquid impact on processing operations.
    - Impact on effluent activity.

2. Ensure the above issues are addressed at the implementation level. In order for the accountable worker to effectively comply with recommendations and requirements, the proper "tools" must be made readily available to them.

CAUTION:	The station should carefully review FSAR and Licensing documents prior to installing drain socks to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

3. Install nylon drain socks in all RCA floor drains. The drain sock's installation, cleaning, and/or replacement should be included in housekeeping routines.

NOTE 1:	The use of drain socks, when properly installed and maintained, will preclude the potential for creating unidentified waste "plugs" in "out of sight" low flow areas. The use of drain socks traps unwanted debris in a dry form in a manageable location.

NOTE 2:	The majority of stations using socks, remove drain covers with pliers or channel lock tools, and either dry vacuum or replace the socks. Radiological impacts related to the majority of drains is minimal as they are located in radiologically clean areas. Those located in contaminated areas present no new challenges, the contamination controls already in place are normally suitable for cleaning/replacement.

4. Label all floor drains with adhesive labels. The labels should clearly communicate the intended use of each drain and any prohibited wastes. The most successful plants use labels that number the drain and prohibit ***all*** liquid wastes from disposal in floor drains without specific concurrence from the radwaste or chemistry manager/supervisor. Adequate pre-job planning would preclude the need for non-emergency and unplanned drainage into floor drains.

5. Install mushroom caps on raised standpipe drains. Installation of mushroom caps precludes the need for temporary covers, prevents installation of hoses into the drains, and allows accumulated liquids on floor surfaces to drain as intended.

CAUTION:	The station should carefully review FSAR, Licensing documents and release permits prior to using process alternatives to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

6. Plug drains in high risk areas to prevent inputs of inappropriate liquids or other materials. Examples include designated storage areas for chemicals, lubricants and painting supplies.

5.3.3 Cross Reference(s):

1. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

5.4 Program Element: Influent Characterization - Analysis Type and Quantity

5.4.1 Program Impact

A key element of a successful liquid waste processing program is adequate chemistry characterization of inputs to processing systems. Many stations currently have a partial liquid waste influent characterization program, however, most programs are of limited scope and available data may not be fully utilized. The information gained from system influent characterization can help to identify process changes to optimize system or component performance. Additionally, the information is useful in evaluating proposed processing enhancements.

For example, if a process component's performance is low relative to similar stations, characterization and a routine analysis of the influent stream can lead to processing improvements.

> **NOTE:** Identifying, and characterizing the sources of LRW to the extent practical is one of the most critical aspects of a successful LRW management program.

Sample analyses should be used as a diagnostic tool for optimizing program performance. As such, it is important to carefully evaluate the sample analyses being performed and their frequency.

It is equally important to clearly identify what sample parameters will provide data that can be used for program performance or improvement analysis. The quality and use of the data is more important than the quantity. Balancing the workload and derived benefit will prevent over-analysis of influent waste streams minimizing the impact on labor and laboratory resources.

5.4.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Include analysis of all major liquid waste inputs on a routine basis.

- Sample plant sumps and collection tanks feeding the processing system on a routine, scheduled basis, and following unanticipated liquid inputs.

- Evaluate data obtained from sampling to identify unwanted source(s) of liquid waste, and to optimize waste liquid processing.

NOTE:	Control of influent water quality is an important element of a successful liquid waste management program. The previously recommended improvements offer opportunity for improved process performance, waste volume and cost reduction, do not require large expenditures, and do not require additional staff.

2. Carefully evaluate sample type and frequency required for each waste stream. When considering these program elements, factors to address include:

   - Expected waste stream characteristics.
   - Individual waste stream impact on liquids combined in collection tanks.
   - Types of liquid process to be used.
   - Typical waste stream influent volume and input rate.
   - Significance of chemistry parameter on process performance.
   - Available analytical equipment and resources. On-line instrumentation that is *credible* provides an excellent tool for operators to use for monitoring system performance.
   - Anticipated quality or volume transients.

3. Routinely analyze system influent for:

   - Activity (isotopic)
   - pH
   - Conductivity
   - Total suspended solids (TSS)
   - Total organic carbon (TOC)/oil and grease

   This basic chemistry data can assist in identifying unwanted inputs and to evaluate alternate processing configurations for recycle or release.

4. Sample and review analyses results as soon as possible, preferably as follows:

   - **System influent** - prior to process system startup, facilitating appropriate process component configuration changes based on identified impurities.
   - **System effluent** - as soon as possible following at least one system volume turnover. Maximum within one hour of process startup to verify satisfactory performance.
   - **Individual component or vessel performance** - weekly or as appropriate based on overall system performance and influent quality.
   - Following any known system or influent transients - influent and effluent samples - immediately.

5. The use of reliable, state-of-the-art in-line monitors has been effective in providing readily available field information to system operators and the plant chemistry staff.

> **NOTE**: Historically, the use of these monitors has required additional instrumentation calibration and maintenance efforts.

5.4.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
4. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".
5. The EPRI document titled "BWR Normal Water Chemistry Guidelines".
6. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
7. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".
8. An industry paper titled "An Overall Crud Reduction Program for Deep Bed Polishers in BWR Nuclear Plants".

5.5 Program Element: Waste Segregation

5.5.1 Program Impact

Commingling low quality and high activity liquid wastes prior to processing may negatively impact processing performance. Low quality liquid will more rapidly deplete processing media and foul filters and membranes and normally results in increased concentrated solids requiring disposal. Several chemical species present in low quality liquids will result in radioactive isotopes being "thrown" from process media.

Additionally, the sludge generated from low quality liquids can be more cost effectively processed if the activity concentration is kept as low as reasonably practical.

As a result, segregation is a useful tool for enhancing process system performance at minimal cost. Using installed systems or low technology processing options, can be significantly less expensive than the use of advanced processes such as demineralization and membranes.

EXAMPLE 1: Processing 500,000 gallons of low quality LRW using filtration and demineralization at an all inclusive cost to the station of $0.25 per gallon, results in a total cost of $125,000. Segregation and use of low technology processing to meet minimal system effluent quality standards could decrease that cost by $0.10 per gallon for a total cost of $50,000 for that volume. This results in a direct savings of $75,000 for the same process volume.

EXAMPLE 2: Processing 500,000 gallons of high quality LRW using filtration and demineralization at an all inclusive cost to the station of $0.25 per gallon, results in a total cost of $125,000. Processing low quality liquids at a reduced media throughput, could increase the all inclusive process cost to $0.35 per gallon for a total cost of $175,000. This results in a direct cost increase of $50,000 for the same process volume.

The use of an alternate routing and collection configuration via existing piping and components can also positively impact processing system performance.

5.5.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

> **CAUTION:** The following recommendation involves reconfiguring systems, or alternate uses of existing systems. The station should carefully review FSARs, Licensing documents and release permits prior to implementing this guidance to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

1. Review existing system configurations to identify potential waste segregation schemes. As part of the review and analysis, consider the following:

    - Physically split existing process systems.
    - Use of retired components for waste segregation.
    - Isolation or designation of portions of an existing system for use with another waste stream (i.e., dedicating one equipment drain tank for floor drain wastes).
    - Procedure modification and operator training to address segregation.

5.5.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
2. The EPRI document titled "Cost-Effective Liquid Processing Programs".
3. The U.S. DOE document titled "Guidelines for Mixed Waste Minimization".
4. The EPRI document titled "Radwaste Desk Reference Volume 4: Mixed Waste".

5.6 Program Element: Alternatives to Processing

5.6.1 Program Impact

Liquid radwaste processing influent quality can be dramatically improved at minimal cost through the use of process avoidance. Low quality, low activity liquid wastes can often be released following sampling and/or in-line monitoring, without unreasonable increases in effluent activity.

5.6.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

> **CAUTION:** The following recommendation involves potential plant liquid effluent characteristic changes. Regardless of the activity acceptance criteria and ability to meet that using this recommendation, the station should carefully evaluate the impact of this recommendation on the plant liquid release dose.

1. Similar to liquid volume minimization recommendations, explore alternate collection and routing for low quality, low activity liquids. The use of portable collection containers, laundry systems and decontamination solution tanks frequently provides an acceptable path for collection, sampling and continuous monitoring during release, without normal processing.

5.6.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI product "waste*WORKS:*Wet Computer Code".
4. The EPRI document titled "Cost-Effective Liquid Processing Programs".

5.7 Program Element: Outage Success

5.7.1 Program Impact

Liquid radwaste processing is one of the most frequently overlooked components of a successful outage. Outage evolutions typically generate significant volumes of waste containing high levels of solids and other impurities. Liquids generated by system maintenance, cavity draining, decontamination, tank and sump desludging, media changeouts and routine housekeeping all contribute to the impurity and solids load forwarded to the radwaste system. When combined with the high liquid waste volumes associated with plant shutdown and startup, the result can often be overwhelming.

Many tasks are repetitive from one outage to the next and the fundamental processes by which the volumes are generated is constant. As a result, careful preplanning related to scheduled outage work combined with anticipation of deviations from that plan can result in successful waste processing. Inclusion of water management controls into the outage schedule combined with documentation of the method leading to a reduction in waste inputs, can result in a sustained improvement in the program.

5.7.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Involve liquid processing program management in outage planning in the initial planning phase.

2. Research historical data and identify all planned liquid volumes and waste stream characteristics.

3. Develop a processing strategy that takes into account the following:

    - Anticipated volume.
    - Typical chemical and activity characteristics.
    - Best possible input schedule window.
    - Optimum treatment method.
    - Minimization techniques.
    - Outage scheduling.
    - Alternatives to processing.
    - Processing support requirements including labor, equipment and materials.
    - Establish progress reporting and feedback method for status and results.
    - Include contingencies for unexpected situations.

5.7.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".

5.8 Program Element: LRW Resulting From Process Media Handling

5.8.1 Program Impact

Impurities and solids are introduced into waste processing streams as a result of carryover from decanting phase separators, carbon vessel backwashing, new and spent media sluicing, and from high integrity containers (HIC) during dewatering evolutions. These sources have the potential to become more significant if used in conjunction with non-precoat filters. The average particulate size that is backwashed can be physically smaller or colloidal due the lack of precoat media to assist in charge neutralization and settling, and therefore will probably be more transportable in decant liquid.

URC systems are used at some stations for condensate deep bed resin cleaning. During cleaning, the hydraulically separated particulate and resin fines are routed to a waste water recovery system in a water slurry for additional treatment and disposal.

As a result of the suspension of undesirable waste products transported from the resin cleaning process, this system influent liquid is generally a low quality waste. This presents a substantial impurity load to waste processing systems, and results in generation of additional solid radwaste. This solid RW contains large quantities of microorganisms capable of acid and biogas production. If the solid RW also contains significant levels of cellulose and other nutrients, biogassing is likely.

5.8.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Establish a program for segregation and alternate processing of low-quality resin cleaning, media transfer and decant liquids. The use of partially depleted media in a HIC as an atmospheric demineralizer for decant wastes has been successfully demonstrated at several utilities. This provides preprocessing prior to routing the waste to installed plant systems, without generating additional solid waste.

2. Use a smaller mesh dewatering screen or progressively decreasing micron rating for lateral filters in the waste processing HICs. This would minimize particle carryover to liquid waste collection tanks during container dewatering evolutions.

3. Route decant liquid wastes back to the spent resin tank to the extent practical. This practice increases the potential for additional decay of short lived nuclides, additional ion exchange, and solids transfer to the next waste package loaded.

4. Carefully evaluate and consider the use of coagulants/polymers in BWR phase separators to agglomerate iron and solids generated using minimum and non precoat elements. This process has the potential to improve phase separation, generating an improved quality decant liquid.

5. Route this waste stream to a separate collection tank for processing using alternate methods as described in Sections 4.3, 4.7, 4.8, 5.6 and 5.7, or using other viable techniques.

5.8.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI product "waste***WORKS:***Wet Computer Code".
4. The EPRI document titled "Cost-Effective Liquid Processing Programs".
5. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

5.9 Program Element: Mop Water

5.9.1 Program Impact

At some stations, floor surfaces in the RCA are routinely cleaned, stripped and waxed. Other stations use commercially available solutions for routine floor and equipment cleaning and decontamination. Frequently, mop water, decontamination solutions and stripper are disposed of directly into floor drains. These solutions, though normally low activity, are typically high in solids, organic materials, and cleaning agents that can result in premature depletion of processing media, not to mention increasing foaming and carryover in radwaste processing evaporators.

> **NOTE:** Cleaning agents can actually promote the transport of organics and activity to the radwaste system. Some cleaning agents will actually complex organics and activity into "non-ionic" species making them more difficult if not impossible to remove with normal processing techniques.

5.9.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Evaluate and implement the use of alternative methods for releasing waste mop liquid. Collect and process mop water as a separate waste stream. This could be accomplished using one of the following options:

    - Use an installed tank such as a laundry or decontamination solution tank as a mop waste collector for filtration and release bypassing other more costly processes.

> **CAUTION:** Drums used for evaporation should be properly ventilated to preclude concentrating noxious fumes that may create an inhalation hazard.

    - Evaporate low quality cleaning liquids using electric drum heaters located under a ventilation hood.

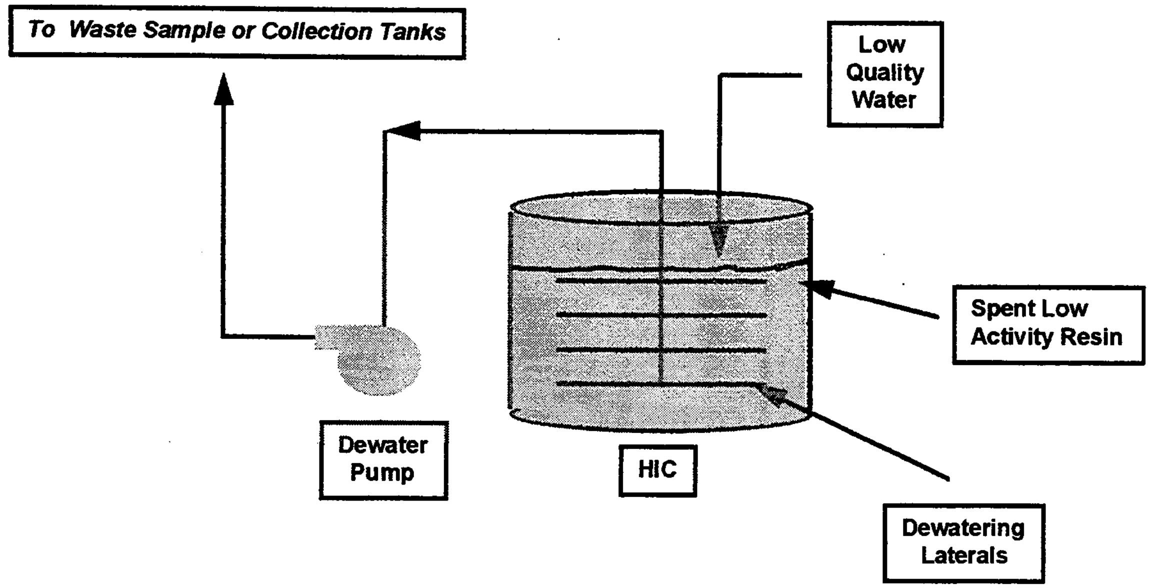
    - Configure a HIC containing partially depleted low activity processing media (i.e., waste SGBD or condensate resin) as an atmospheric demineralizer to process the low quality waste liquid. Figure 5-1 contains a simplified diagram of this concept.

    - Clearly labeling all collection containers for their intended use. It is also a good practice to include on the label, those inputs not permitted in the collection container (i.e., lubricants, residual chemical waste etc.).

2. Mop water generated at RCA access and egress areas should be disposed as radwaste to preclude concentration of trace contamination in sewage treatment facilities.

3. Eliminate the use of chemical cleaners for routine mopping. Reserve cleaning agent use only for those applications where it is required to breakdown lubricants or heavily soiled areas.

Figure 5-1 Low Quality Liquid Waste Processing



5.9.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".

5.10 Program Element: Organics

5.10.1 Program Impact

Regardless of the materiel condition of a station, sumps typically concentrate some volume of oil, EHC fluid, or glycol. The fluids are introduced to the radwaste processing system via component seal leakage, larger volume spillage, or frequently during fluid addition to components as a result of improper addition containers or devices. As a result, the fluids can be emulsified during sump or collection tank pump operation and forwarded to the radwaste system(s). This is especially true if liquid is being introduced at the same time the pump is actually in operation. These fluids negatively impact processing operations and effluent liquid quality.

This factor is most significant for stations recycling processing system effluent for use in the condensate, feedwater or reactor coolant systems.

5.10.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Identify and eliminate or minimize inputs to sumps and collection tanks.

    - Consider establishing a small task force or dedicate a specific team to effect repairs of oil leaks and for optimizing lubrication management. The team should, as a minimum, consist of support from the Operations, Maintenance, and Engineering organizations. Empower the team to ensure completion of the task once the effort is started.

2. Develop and implement an oil/EHC/glycol control program. The fluids should be tracked through warehouse issue, component addition, to removal or replacement (changeout/PMs). This will result in positive fluid volume tracking, fluid system/seal performance monitoring, and more rapid identification of abnormalities.

3. Install portable mechanized oil skimmer systems on sumps that routinely experience oil input. These inexpensive skimmers are used successfully at several utilities for consistently troublesome sumps and do not create additional waste during the separation process. One station resolved "splatter" problems with the tubular type of skimmer by encasing the tygon tubing in a large diameter PVC pipe sleeve from the skimmer to the top of the sump.

> **CAUTION:** The use of floating oil absorbent pads in sumps results in the generation of additional solid radwaste requiring disposal. The floating pads can potentially result in sump level switch or pump malfunctions and Additionally, the pads can leach chemicals integral to the pad design, that are forwarded to downstream processing components.

4. Use oil pads on oily water separators to remove residual surface oil.

5. Work with operations and maintenance personnel to evaluate and procure the correct fluid addition devices. The use of small polyethylene squeeze bottles available in commercial laboratory supply catalogs has been successfully implemented at some stations to add lubricants to plant equipment.

6. Consider replacing cellulose containing materials.

5.10.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".
4. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".

5.11 Program Element: Laundry Waste

5.11.1 Program Impact

The majority of plants do not launder protective clothing (PCs) on-site and therefore do not generate liquid laundry waste. They have instead opted to have PCs cleaned by a contracted vendor at an off-site facility. A few stations are using on-site contracted vendor processes, generating some laundry waste requiring additional processing prior to recycle or release. Still other utilities operate installed laundry facilities solely for specialty cleaning. This can include items such as a select portion of the PCs used, mops, or waste collection bags.

When generated on-site, liquid laundry waste contains concentrated solids removed from garments, fabric lint, and laundry cleaning solutions. If combined with other liquid waste, this impurity loading will negatively impact liquid processing operations, resulting in more rapid filter and/or membrane fouling, more rapid ion exchange material depletion, or carryover of impurities in evaporator effluent distillate.

5.11.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Carefully evaluate the cost benefit of on-site laundry operations. As part of that assessment, consider the following issues:

    - Impact costs for liquid processing - labor, media costs, packaging and disposal.
    - Labor to sort, clean, monitor and re-sort/fold laundry items.
    - Equipment replacement component costs, maintenance labor and monitoring calibration/source checks.
    - Impact on processing system effluent quality and activity.
    - Alternate use of facility or space occupied by laundry equipment.

- Radiological controls costs - labor, materials, radiological hazard potential.
- Alternate use of staff required for process.

2. Require on-site laundry contractors to minimize liquid volumes, optimize pretreatment prior to transfer of liquids to the station (e.g., thermal treatment), and the use of cleaning solutions that do not negatively impact plant specific liquid processes.

3. Use alternate on-site laundry process technologies such as ozone or microwave cleaning.

4. Segregate the waste stream for alternate processing. This typically consists of filtration without demineralization.

5. Maintain laundry waste stream strainers intact to prevent fouling downstream processing media/components.

5.11.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".
4. The EPRI document titled "EPRI Guide to Managing Nuclear Utility Protective Clothing Programs".

5.12 Program Element: Precipitation, Exterior Moats and Ground Water

5.12.1 Program Impact

These waste streams are typically not radioactive, but are high in impurities. They can rapidly deplete normal processing media and can also promote microbial growth. At several stations, analysis of ground water indicated the presence of significant amounts of calcium, most probably a result of structural concrete leaching or groundwater intrusion. Water collected in exterior moats (often associated with tank farms), is typically high in impurities including biological matter, calcium, and sodium that negatively impact processing operations. Additionally, ground water intrusion can be incorrectly identified as the source of undesirable inputs, masking other sources of low quality LRW generation. The more successful programs address this waste with administrative guidance permitting sample and release without processing.

5.12.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Minimize the volume of rain water that requires processing.

    - Identify and repair all roof leaks.
    - Implement proceduralized periodic inspections for roof leak identification. This can be accomplished through surveillance test or PM program incorporation.

2. Identify and repair ground water leaks. Several stations successfully use sealant injection contractors to minimize or eliminate ground water intrusion.

3. Eliminate the source(s) of exterior moat contamination and/or decontaminate the moat as necessary for free release, eliminating the need for routine processing for this waste stream.

4. Leakage that cannot be eliminated should be contained for collection, sampled and free released without processing if appropriate.

5.12.3 Cross Reference(s):

Report Section 4.4 - Leak Repair & Prioritization
Appendix A - Reference(s):

1. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
2. The EPRI document titled "Cost-Effective Liquid Processing Programs".

5.13 Program Element: Miscellaneous Secondary System Waste

5.13.1 Program Impact

Uncontrolled leakage and draining of the water from these systems can present a ***major burden*** on LRW processing media such as ion exchangers. This water contains organic material used for the corrosion treatment, dissolved solids (such as nutrients) and other impurities. These shorten the service life of ion exchange resin and filter media, and increase operating LRW program costs. Additionally, for recycled water, they can negatively impact both LRW system effluent quality and subsequently feedwater chemistry.

EXAMPLE: One station has successfully reduced the impact of low quality liquids using an input identification matrix. The table provides chemical and radioisotope characteristics for easy identification of processing system influent sources. The table contains a matrix similar to the following example.

Source	pH	Conductivity	Chemical Tag	Radioisotope
RCS [1]	5.5	25-35	None	High ratio (Co 58/60)
Service Water	8.4	1,790	Chlorides 450 ppm	None
Chillwater	9.0-9.1	4,000	Nitrites 500 ppm	None

NOTE 1: The matrix should include normal RCS parameters for use when comparing data or commingling waste streams in sumps and collection tanks.

CAUTION 1: Several of the following considerations involve reconfiguring systems, or alternate uses of existing systems. The station should carefully review FSARs, Licensing documents and release permits prior to implementing this guidance to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

CAUTION 2: Several stations use yard drains for releasing secondary waste streams following chemical and radio analysis. The station should carefully review bulk sample procedures, FSARs, Licensing documents and release permits prior to implementing this practice. The review should verify regulatory compliance with processing and continuous monitoring during release definitions and requirements. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

5.13.2 Guidance - Service Water

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Similar to the guidance provided in Section 4, establish drain paths for releasing the waste water without processing. The liquid should be sampled and/or monitored during release to ensure compliance with plant requirements.

> **EXAMPLE:** At least one station makes use of the negative pressure created by service water pumps to vacuum drag water from the header isolated for work, to the header currently in service. This allows rapid water movement and no secondary waste is created.

2. Perform an analysis using corrosion inhibitor addition logs and makeup water addition rates, to identify system leakage. Warehouse issuance of corrosion inhibitor may be misleading as that typically includes all stock issued, but not necessarily added to the system to date.

3. Similar to recommendation 2, perform the same analysis for biocides used for treating the liquid stream.

4. Use chemistry data to develop a plant specific input identification matrix for secondary waste streams. The matrix should include normal RCS parameters for use when comparing data or commingling waste streams in sumps and collection tanks.

5.13.3 Guidance - Closed Cooling System Waste

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Establish water management plans based on required maintenance or performance testing to optimize treatment and/or disposition practices.

2. Collect and recycle as much of the generated volume as practical. The cooling water should be sampled and its reuse approved by the chemistry organization.

5.13.4 Guidance - Fire Protection System Waste

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Evaluate periodic system flush requirements versus benefit derived. Consider reducing the flush time to minimize LRW generation.

2. Consider the use of high quality water in fire protection systems to minimize nutrient inputs into LRW.

3. Use component specific fittings and hoses to route flush water to clean waste headers or release monitor tanks, bypassing normal LRW processing.

5.13.5 Cross Reference(s):

Appendix A - Reference(s):
1. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
2. The EPRI document titled "Cost-Effective Liquid Processing Programs".
3. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

5.14 Program Element: Sumps & Tank Cleaning

5.14.1 Program Impact

As previously discussed, sumps and tanks are concentration points for many undesirable waste inputs. They can accumulate oil, solids, a variety of chemical species, including organics. When LRW processing systems are challenged by waste having these characteristics, it can result in:

- Decreased processing media throughput.
- Increased solid waste volume.
- Increased personnel exposure.
- Increase program costs.

It is known that some of the inputs such as oil and solids are not easily transported by sump or tank liquids as a result of differing material densities. However, pump operation or chemical interactions can result in formation of more readily transportable impurities by complexing oils or solids. Routine sump and tank cleaning will minimize that potential by eliminating the undesirable species, thereby precluding their input to the processing stream. These solids are important sources (food) for growth of microorganisms that can result in biogassing. When properly managed, these inputs will have minimal impact on processing system performance, program costs and solid waste disposal volumes.

5.14.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

CAUTION:	The station should carefully review final safety analysis reports (FSAR), Licensing documents and release permits prior to using process alternatives to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

1. Use nylon drain socks and good housekeeping practices to minimize the need for sump and tank cleaning.

2. Cleaning sumps and tanks on a scheduled basis. The best programs use performance based criteria for determining cleaning frequency.

   Several of the criteria used include:

   - Sump or tank dose rates.
   - Process system influent chemistry data.
   - Historical data on solids buildup.
   - Visual inspection.

3. Sumps and tanks accessible during normal plant operations should be scheduled for cleaning following outages to minimize outage impact by removing the larger concentration of impurities associated with outage work. Initial cleaning evolutions will most likely generate large volumes of solids and other impurities. However, following implementation of controls previously discussed in this document and as a result of routine cleaning, will yield smaller cleanout waste volumes.

4. When cleaning tanks, the use of remote or extension technology will significantly decrease personnel exposure with satisfactory results. The use of robotic track or hover sparging and vacuum equipment is effective for most tank cleaning. Several utilities own this equipment others contract robotics vendors for cleaning operations.

5. Sumps can be effectively cleaned by using powerful wet pump-vacuum systems with extension wands, recircing the pump-vacuum effluent through portable filters back to the sump. This results in solids removal and minimal liquid waste generation.

6. Use installed sump and tank recirculation equipment to routinely recirculate the contents, minimizing solids settling and sludge accumulation.

5.14.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

5.15 Program Element: Chemistry Sample and Laboratory Waste

5.15.1 Program Impact

Routine chemistry analysis result in the use and disposal of various chemicals. This waste stream adds undesirable species to the liquid waste systems, negatively impacting the processing operation.

5.15.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Consider the use of available alternative chemical analysis techniques and methodologies. Research alternatives and where applicable implement new methods.

> **EXAMPLE:** At least one station has tested and implemented the use of analytical procedures and techniques that minimize the chemical impact on processing operations. This includes environmentally acceptable scintillation cocktails.

2. Characterize the waste stream and evaluate the use of alternate processing methods for this waste water rather than complete demineralization. The use of filter and release systems such as a laundry waste tank or decontamination solution tank may be appropriate.

5.15.3 Cross Reference(s):

1. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

Section 6 Optimizing Liquid Waste Treatment

6.1 Overview

Filtration, separation, demineralization and evaporation are the fundamental technologies used for liquid waste processing. The methods available are varied in both applicability and technology, therefore it is essential that the liquid to be processed is thoroughly characterized prior to selection of a specific process technique. Additionally, it is important to recognize that filtration is typically intended to target insoluble species and demineralization soluble species, whereas evaporation is intended for both. The effectiveness of a processing configuration can change rapidly with variations in influent sources. The most successful process schemes require that the waste stream stability be maintained.

The general waste stream characteristics that should be evaluated prior to developing a processing strategy include:

- Influent pH.
- Conductivity.
- Particle size and abundance using various techniques.
- Activity (total and isotopic).
- Organic concentration.
- Chemical presence and concentration (i.e., boron, closed cooling water treatment chemicals).
- Microorganism abundance ("food" supply).
- Anticipated variations in influent quality.
- Process volume.

Prior to filter selection, the waste stream should be further characterized to identify inputs from external sources that impact filtration efficiency.

EXAMPLE: At some stations, an external process with significant impact is URC. URC waste water contains resin fines and insoluble iron removed from the station's deep bed condensate polishers. BWR iron is small in size (<2μm) and can be colloidal due to the absence of charged counter-ions. The majority of the corrosion products in a BWR are in the form of hematite, magnetite, and amorphous iron. The percentage of magnetite present in BWR corrosion products is generally small. Magnetite, due to its crystalline structure, is easier to filter than the other forms of iron. Amorphous iron on the other hand, is more difficult to filter and presents long-term filtration problems by strongly adhering to the filtration media. The corrosion products and their concentration can play a major role in determining the performance of filtration systems.

Defining the performance acceptance criteria for LRW processing is a difficult task. At many utilities those criteria are dependent on reasonable efforts, while at others processing is complex and costly. In order to define what is "reasonable" processing, several aspects of the program should be evaluated, including the following:

- Liquid processing goals [i.e., recycle or release, reduction in effluent activity or a chemical specie(s), feedwater quality].
- Ability to meet recycle or release criteria and efforts to continually improve process performance.
- Effective holdup capacity.
- Cost of processing versus benefit.
- ALARA impact.
- Waste packaging and handling efficiency.
- Prioritization to ensure easy to resolve issues are dealt with prior to more complex issues.

Following characterization of the liquid waste stream and evaluation of the above issues, a review of available technologies is necessary prior to process technology selection. The available technology has changed significantly in the past decade by combining nuclear experience and lessons learned, advances in processing materials and cross-over technology from other industries. This section addresses technology currently available to the industry.

6.2 Program Element: Tank and Water Management

6.2.1 Program Impact

Managing tank capacity and water movement are important elements of successful LRW processing programs. Proper planning can result in maximization of holdup capacity with minimal movement of LRW, taking into account routine and surge volumes, and outage inputs. Additionally, tank management programs should consider evaluation of routine removal of liquid "heel" volumes present after pump-down cut-off (e.g., using manual override) to minimize cross contamination (e.g., RCS recycle hold up tank pump down).

6.2.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

> **CAUTION:** The station should carefully review final safety analysis reports (FSAR), Licensing documents and release permits prior to using process alternatives to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

1. Review historical data and develop operational and outage holdup capacity management plans. The plans should focus on minimizing processing and water movement and maximizing waste stream segregation. The use of system components and piping outside their original design configuration may result in enhanced program performance.

2. Devise methods and/or procedures to minimize residual waste in tanks following pump-down. These techniques can include:

> **CAUTION 1:** The station should carefully review final safety analysis reports (FSAR), procedures and Licensing documents prior to using process alternatives to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

CAUTION 2: The use of manual pumping operations requires careful operator oversight to prevent pump cavitation and potential damage.

- Using manual overrides to pump tanks down to the pump's minimum operational level.
- Using installed or portable recirculation systems to ensure the residual heel is turned over on a frequent basis, minimizing solids settling and sludge accumulation.
- Removing tank's residual LRW with portable pump systems on a periodic basis.
- Manual draindown.

3. To the extent practical, establish plans for unanticipated surge volumes, minimizing the impact on processing operations.

4. Develop a processing plan for use during periods of high waste generation such as outages. Incorporate the use of alternates to processing as discussed previously in Sections 4 and 5. Ensure that the strategy addresses utilization of available tankage to maximize decay of short lived isotopes while maintaining adequate reserve volume for unanticipated inputs.

EXAMPLE: Several stations ensure holdup tanks are emptied prior to the start of an outage, and that LRW management is incorporated in the outage plan. As a result, LRW containing short lived isotopes such as Co-58 can be retained for extended periods for decay, resulting in reduced effluent activity and processing media demands.

6.3 Program Element: Chemical Pretreatment

6.3.1 Program Impact

Chemical pretreatment of liquid radwaste can improve the performance of filtration and ion exchange units. The use of chemical additives can also result in enhanced process performance including reduced solid waste generation and reduced effluent activity. Additionally, chemical pretreatment has proven to be effective for improving particulate settling for phase separation.

The success of chemical pretreatment is plant specific. Two types of chemical pretreatment have been successful at several plants. Adjusting pH is one method. Reduction of pH can convert complexed and colloidal metals into a soluble form increasing the overall effectiveness of organic ion exchange media.

The addition of polyelectrolytes is the other pretreatment method that has been successful. One polyelectrolyte has converted some forms of colloidal metals into a species which can be removed by organic ion exchange resin. Other polyelectrolytes can coalesce colloidal metals into larger particles suitable for filtration by layered carbon beds.

6.3.1.1 pH Adjustment

Stabilization of influent waste water pH through metered injection of NaOH has been successfully used at some plants to improve demineralizer decontamination factors and media throughput.

Under conventional processing methodologies resin induced pH swings can be significant, affecting performance of downstream beds. This can require frequent re-sequencing of beds to minimize the impact on downstream vessel performance. When using chemical pretreatment, pH swings can create chemical conditions outside the optimal range for organic media, and can result in acid wash, sloughing and poor performance.

EXAMPLE: At one station, to address the affect of pH wings, the influent stream pH is monitored by and in-line probe to control NaOH injection, maintaining the influent pH to 7.0. Sodium form cation resin is used, replacing the traditional hydrogen form cation, precluding pH swings downstream of a chemically active bed. Anion resin, when required, is placed at the end of the system to minimize the impact of a pH swing on the system. To restore pH to meet release limits, acid injection is used on the effluent when a chemically active anion is in service.

In this environment, cesium tends to be weakly bonded to the sodium form cation resin. The sodium form cation is operated past cesium break to cobalt break. Downstream of the sodium form cation, a synthetic cesium selective zeolite is used for cesium removal. It is operated past cobalt break to cesium break. This processing methodology is effective for 90% of that plant's waste water.

Typically, 90% of that plant's LRW processing problems result from 10% of the plant's inputs. In particular, resin sluice waster frequently presents cobalt in a fine particulate state or in complexes that pass through the system unaffected by demineralization or filtration. These inputs are sometimes effectively treated by isolating the liquid and reducing the pH to less than 5.0. The LRW is recirculated for a minimum of 24 hours allowing cobalt to return to a soluble state. This improves the ion exchange efficiency during subsequent reprocessing operations. Similar to all LRW influent streams, the pH is maintained at 7.0 as it enters the processing skid.

The cumulative effect of this treatment methodology has resulted in greatly improved media throughput, reduced processing costs and standardized treatment methods.

Typical performance for the station in the previous example is listed below:

Media	Throughput (Gallons per ft3)
Carbon	55,000
Hydrogen form cation	70,000
Sodium form cation	90,000
Cesium specific	250,000
Anion	50,000

6.3.1.2 Polyelectrolyte Addition

Several methods of polyelectrolyte addition to influent LRW has been successfully used to remove colloidal cobalt. This technique was very successful I solving colloidal cobalt problems at several plants in the 1980s. Several PWRs found that this method failed upon moving from coordinated reactor coolant chemistry to the modified lithium regime.

The addition of small amounts of low molecular weight cationic polyelectrolyte and salt has been able to convert troublesome colloidal cobalt into a species that can be removed by organic cation resin. This process adds 10mg/l of salt (non-iodized) to batches when the conductivity is below 50 μmho/cm. The polyelectrolyte is then added at the appropriate amount (e.g., 0.1 to 10 mg/l) for optimal DF. Bench scale column testing can be performed to determine the optimal quantity of polyelectrolyte addition. Should the column tests indicate that polymer addition has no effect on DF, reference document guidance recommends that 0.1 mg/l should be added to the full scale batch.

EXAMPLE: Using this formula, one plant was able to increase throughput from 2,000 gallons per ft^3 to 33,000 gallons per ft3 of media.

The addition of different polyelectrolytes has been able to convert colloidal cobalt into filterable particles at several plants. This pretreatment method is used in conjunction with top sluice layered carbon beds. A top sluice carbon bed is desirable to preclude rapid increase in the differential pressure across the carbon media, increasing solid waste generation.

For batch application, the correct dosage of polyelectrolyte should be determined using bench scale testing. The proper dosage can be correlated to influent turbidity. The polymer is usually injected into the treatment liquid during processing versus directly into the tank, fed upstream of the carbon filter vessel.

Polyelectrolyte addition can also be used for improving particulate settling. The use of minimum and non precoat filters results in a reduction in solids (iron oxide) settling efficiency. The particulate is then transported via the decant liquid to the LRW system, severely challenging that media. The use of polymers phase separation evolutions, can enhance solids separation and settling, minimizing the impact of decant liquid on LRW processing media.

EXAMPLE: A two unit site was retro-fitted with deep bed demineralizer vessels downstream of pleated non-precoat filters. This resulted in a significant reduction in radioactive waste generation.

The contents of the backwash receiving tanks are transferred to one of four 400 cubic foot condensate phase separators. After settling, the upper (liquid) portion of the phase separator is decanted to the LRW collection tank. The lower portion is allowed to accumulate solids until it is economical to process the solids into a HIC for disposal. The smaller iron oxide particles, no longer combined with spent media, were not settling in the phase separators. This heavy loading of small particles was choking the LRW filters, and later the HIC filters.

At this point, the system was producing recycle quality water, but resin usage was resin loading was 25% higher, and backwashes more than doubled. Chemistry samples for jar tests were taken from the discharge side of the phase separator sludge pumps. Phase separator decant samples were also used for some tests. Resin columns using mixed bed resin and/or activated carbon were used to test the effects of the additives on the deep bed.

The most consistent results were obtained using a commercially available polymer with NaOH addition for pH control. Polymer and caustic, followed by a demineralized water rinse, were pumped into the phase separator. Equipment drain filters were now processing significantly higher volumes. 15 cubic feet of granular activated carbon placed on top the deep bed further enhanced the process.

6.3.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

> **CAUTION:** The station should carefully review final safety analysis reports (FSAR), Licensing documents and release permits prior to using chemical additives to ensure system material compatibility and regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

1. Ensure careful oversight is maintained to preclude pH swings that can result in acid wash, sloughing and poor performance.

2. If colloidal metal is a problem, perform bench scale testing to determine if polyelectrolyte addition can improve:

    - Cation resin performance.
    - Carbon filtration performance if a layered carbon bed is available.
    - Particulate (iron oxide, solids) settling in phase separators/settling tanks.

3. If bench scale testing is successful, consider implementation of full scale polymer addition.

4. Polymers can be added using several techniques including:

    - The use of taps on the suction side of tank recirculation pumps for salt and polymer can be addition through induction.
    - Injection of polymers using flexible tubing connected to pump suction vent taps and routed to a mixing/addition container.
    - Addition of the polymer by throttling open an isolation valve while the tank pump is recirculating tank liquid.
    - Use a metering pump to provide a controlled addition of polymers.

6.3.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. An industry document titled "Reduced Particulate and Colloidal Cobalt Activity in Liquid Radwaste".

3. The EPRI document titled "Pretreatments and Selective Materials for Improved Processing of PWR Liquid Radioactive Waste".
4. An industry document titled "The Application of Polyelectrolyte to Improve Liquid Radwaste Treatment System Radionuclide Removal Efficiency".

6.4 Program Element: Single-Use Cartridge and Bag Filters

6.4.1 Program Impact

Filters by definition are intended to remove insoluble particles from a liquid waste stream as a stand alone effort, or to provide protection to follow-on demineralizers or other advanced process technologies.

Short, inconsistent filter runs can make the overall processing system inefficient due to reduced effluent quality, reduced processing rates, depleted filter media and associated labor and disposal costs.

> **CAUTION:** The station should carefully review final safety analysis reports (FSAR), Licensing documents and release permits prior to using process alternatives to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

6.4.1.1 Selection and Loading Logic

Developing a set of selection criteria for a single use disposable filter requires knowledge of both process application and available alternatives. When selecting a filter, the base analysis outlined in Section 6.1 should be used to thoroughly research the intended function of the filter and the "typical" characteristics of the liquid waste to be processed. Several additional considerations are specific to filtration processing.

Micron rating versus application

A sub-micron filter used in a process and release scenario can, dependent on the waste stream, provide little additional benefit at a substantially increased cost. Similarly, a small micron filter as the lead component in a demineralizer train or with an evaporator used for processing low quality floor drain wastes would foul frequently with minimal resultant benefit.

Anticipated waste stream characteristic fluctuations
Off-standard inputs to the system can seriously challenge the performance of the filter. A large influx of decontamination, housekeeping liquid waste, or auxiliary cooling water (river, lake, ocean) could rapidly blind a bag or cartridge filter.

Cost versus application
The costs associated with filtration are directly related to specifications provided by the site and the filter manufacturer. The cost can vary dramatically with minor changes in filtration specifications.

Material versus VR and disposal options (i.e., incinerability)
The VR and disposal options and costs are largely based on filter material and activity. Several of the VR options available for filters include chopping, shredding, supercompaction and incineration of filters constructed of certified incinerable material. Depending on the nature of the solids collected, biogassing may occur in waste containers.

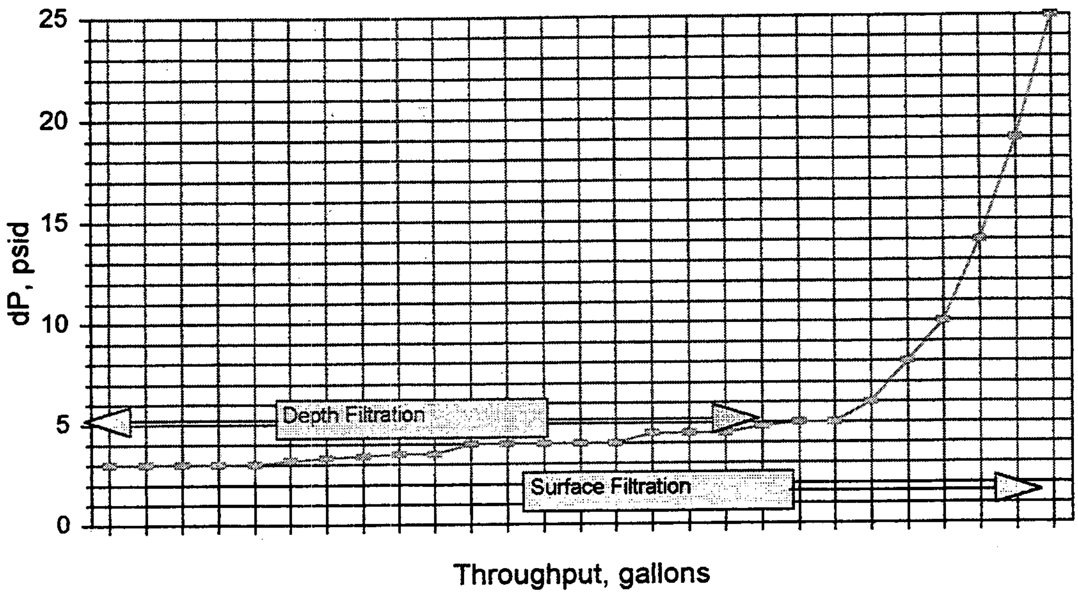
Flux & square feet of media
The rate at which a filter will be fouled is directly influenced by the filter flux (process flow rate per area of filter media-gpm/ft^2), and the waste stream characteristics. This knowledge is critical when developing a filter selection specification to ensure filter performance is optimized.

6.4.1.2 Operation

The majority of filters are in service until predetermined differential pressures (dP) or dose levels are attained. The waste stream characteristics impact both of these factors, again stressing the importance of an accurate characterization. Differential pressure is indicated by installed instrumentation and the maximum dP is typically established by the manufacturer to preclude a decline in filter performance, membrane failure, or cartridge collapse.

The filter dP directly impacts the flux through the filter modifying its ability to effectively filter particles at the design flow rate, as well as potentially impacting filter feed pump operation. Figure 6-1 shows a typical filtration dP curve indicating the filtration characteristics at varying dPs and volumetric throughputs.

Figure 6-1 Typical dP versus Throughput Curve



During outage periods, the potential exists for higher volumes of liquid waste in parallel with a significant increase in particulate impurities. Low quality liquid wastes will result in more rapid filter fouling, increasing process related costs and waste disposal volumes. These factors negatively impact processing operations by challenging holding tank capacity, release tank capacity, and filter performance. Many stations successfully use portable filters both as a primary method or pre-processing of low quality LRW. The applications include reactor cavity, cavity drain down and sump/tank cleaning evolutions.

6.4.1.3 Changeout

Activity limitations are frequently determined by site radiological controls or radwaste organizations based on the measured dose rate adjacent to the filter housing. When determining change out criteria for filters, it is important to consider more than the filter's dose rate relative to ALARA and the dP based on manufacturers recommendations. As the activity of a filter increases, the associated packaging, shipping and disposal costs increase significantly. In many cases, the procurement and waste VR cost savings associated with increased throughput are off-set by activity and waste class cost increases. The extreme case is generation of greater than Class C waste for which no "normal" disposal options currently exist.

The majority of sites assign an exposure cost value per person-Rem. This cost should also be considered when evaluating changeout criteria.

6.4.1.4 Waste Packaging & Disposal

As discussed previously, the packaging and disposal options are primarily controlled by the filter's activity and VR processes. Additionally, these program elements are impacted by:

- Plant structural and space constraints.
- Waste concentration averaging.
- Available plant VR equipment.
- Disposal availability (long and short term).
- Disposal pricing structure.
- Available vendor services.

6.4.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

6.4.2.1 Selection and Loading Logic

1. Evaluating all goals that impact filter selection and change-out criteria. Include the following in the analysis:

    - **Costs** associated with personnel exposure, filter procurement, change-out and disposal.
    - ***Exposure*** associated with reduced source term, filter change-out, packaging, and disposal.
    - ***Actual benefit derived*** from reduced micron rating by liquid system, rather than as a broader philosophy that lower micron ratings are better.
    - Impact of particulates on equipment and/or other processing media such as resin.

2. Formalizing procedures, schedules and planning for filter selection based on known plant evolutions.

3. Ensure that the filter micron rating is commensurate with the intended function. The waste stream characterization, processing system goals, and process flow rate should be used to select a micron rating for the desired performance. In general, the use of sub-micron filters as lead filters for waste processing is not recommended. The implementation process for sub-micron filters should be a "stepped" approach, decreasing the micron rating over a period of time to permit system particle size reduction with minimal filter waste generation.

4. Anticipated waste stream characteristic fluctuations should be incorporated into the filter specification as appropriate. Known fluctuations or expected perturbations based on planned and projected plant evolutions should be analyzed for impact on filter performance. Consideration should be given to specifying a multiple range of filter element ratings for a single housing to address this issue.

5. Following process stream characterization, develop separate detailed procurement specifications for each filter application. Avoid the use of a single generic filter design for different waste streams for the sole purpose of streamlining the procurement and on-site warehousing process.

6. Evaluate the filter procurement and disposal cost versus application in the system. Filtration of a liquid to the maximum extent possible is not always cost effective and may not result in a justifiable derived benefit. Utilize "off the shelf" filters whenever possible to minimize the cost increase associated with custom designs and manufacture. The increased cost associated with absolute or sub-micron filters is difficult to justify for process and release applications, unless particulate activity is a major portion of the nuclides released.

EXAMPLE: Recently, a few stations have successfully utilized sub-micron filtration on the effluent of their processing system as a polishing process to reduce effluent activity. This cost should be analyzed in conjunction with applicable processing program goals.

7. Incorporate ***VR and disposal*** options in the filter selection evaluation. The use of incinerable filters in low activity applications may result in substantially reduced volumes and related disposal costs. Filter choppers and shredders will also result in VR, increased packaging efficiency and an increased waste density. This would potentially result in the minimum disposal cost assuming site specific contracts are analyzed and optimized waste densities are defined based on that analysis.

8. Target minimum ***filter flux*** in the selection process. The filter surface area should be maximized through the use of longer or larger filter elements, more filter elements, or filters presenting more surface area through the use of pleats, etc.

6.4.2.2 Operation

1. Evaluate the component and manufacturers dP rating, and operate the filter to a value below the filter cartridge manufacturer's recommended maximum dP to preclude filter failure.

> **NOTE:** Vendor recommendations can be intentionally low – they can be challenged for improved throughput.

2. Monitor the filter dP over the life of the filter.

3. Anticipate fluctuations in influent quality and have pre-approved alternate filter types available for use as appropriate.

4. Reduce system flowrate and filter flux to the extent practical. This will increase filter efficiency and loading prior to reaching the dP endpoint.

6.4.2.3 Changeout

1. Evaluate the impact of a waste classification on filter operation. Define the costs associated with filter activity versus the cost for spent filter packaging and disposal. Based on this data, develop an optimum upper and lower activity limit.

> **CAUTION:** Ensure limits are restrictive enough to preclude generation of >Class C waste.

2. Perform an analysis to determine the filter activity versus dose rate correlation using the waste stream 10CFR61 isotopic analysis results, filter and vessel construction, and shielding models. The use of historical data can enhance this process, providing actual media data. Based on that analysis define an operating limit related to the filter housing external surface dose rate.

3. Evaluate the activity limitations and associated personnel exposure "cost" versus new filter, changeout and packaging labor and disposal costs. Establish cost effective filter activity limits based on this analysis.

4. Establish an ALARA spent filter handling process. This process may employ the use of transfer bells, and remote grips, tooling and video monitoring and recording. Recent advances in these areas have resulted in significant dose reduction and reduced costs.

Minimize multiple "picks" of spent filters typically associated with storage adjacent to the filter housing, packaging preparation, dewatering and final transport for disposal.

> **NOTE:** Video recordings have proven to be useful training and pre-job briefing tools at several stations.

6.4.2.4 Waste Packaging & Disposal

1. Review activity limits developed above relative to filter dose rate, VR and disposal. Where applicable, adjust limitations to maximize the use of VR techniques and minimize disposal costs.

2. Analyze the disposal fee structure to define the most cost effective filter packaging density and activity. Include as part of that analysis items such as density and activity changes on transportation fees and packaging and disposal options.

> **CAUTION:** Ensure changes to packaging strategies remain in compliance with the Process Control Program (PCP), and container Certificates of Compliance (C of C) and procedures.

When evaluating waste packaging requirements, include the following:

- Container material, size, weight and cost.
- Stabilization requirements.
- Density impact.
- VR and packaging efficiency.
- Dose rate.
- Packaging equipment requirements.
- Burial site specific criteria (e.g., activated metals from clean-up projects.

3. Evaluating increases in waste classification due to VR and/or increased packaging efficiencies to ensure the parallel increase in packaging and disposal costs is less than the cost associated with the originally higher volumes at a lower specific activity and waste classification.

4. Analyze spent filter VR practices to ensure that the increased packaging efficiency does not increase the specific activity of nuclides such as carbon-14, nickel-63, or transuranic (TRU) to levels that result in > Class C waste.

5. Analyze the site structural layout to ensure filter VR, packaging and transport preparation evolutions are optimized. As part of that evaluation consider alternate use of existing facilities, addition of simple, cost effective alterations, and removal of equipment "retired in place" for optimizing the use of alternate space.

6.4.3 Cross Reference(s):

Appendix A - Reference(s):

5. The EPRI document titled "Radwaste Desk Reference, Volume 3".
6. The EPRI document titled "Cost-Effective Liquid Processing Programs".
7. The EPRI product "waste*WORKS*:Wet Computer Code".
8. The EPRI document titled "Low Level Waste Characterization Guidelines".

6.5 Program Element: Precoat Filters

6.5.1 Program Impact

Precoated filters are used as a stand alone filter/demineralizer or as prefiltration and demineralization prior to a deep bed demineralizer. When properly utilized, they are an effective processing tool, however their use can be costly consuming large volumes of media. Typically, condensate filter/demineralizer systems generate the most significant radwaste volumes.

The effectiveness of this process is dependent on a number of variables that are applicable to any precoat filter use including the following:

- Influent impurity concentration
- Influent impurity morphology
- Vessel flow rate
- Vessel flux
- Temperature
- Organic concentration (TOC)
- Precoat material
- Premix or component precoat media
- Precoat overlays and/or underlays
- Resin ratio
- Fiber type
- Precoat quantity
- Precoat quality/concentration/rate (uniformity)

- Element type
- Differential pressure
- Backwash type
- Maintenance history (modifications)
- Body feed

Failure to adequately address these issues can result in:

- A reduction in effluent quality.
- Increased processing costs.
- Irreversibly fouled filter septa.
- Increased waste disposal volumes.
- Increased personnel exposure.

This section addresses several program elements applicable to both radwaste and condensate processing systems. Detailed condensate filter/demineralizer guidance can be found in Appendix A, Reference 7.

6.5.1.1 Media Selection, Blending and Loading Logic

Similar to cartridge filters, prior to media selection, the process stream characteristics, process function and goals must be defined. Several additional factors must also be considered that are specific to precoat.

Media may be procured as an "off-the-shelf" blend or the ratio of cation resin, anion resin and fiber can be custom blended to the plant specifications based on chemical or physical characteristics. Previously, powdered resin premix products had traditionally been available only in stoichiometric ratio. This recent change by resin suppliers to produce higher cation to anion ratio premix products, allows plants to develop custom ratios where required to optimize the precoat of individual components to meet site specific objectives. However, a small number of plants continue to mix the precoat materials on-site. This approach can produce desired precoat blends, however it does have the undesirable aspect of introducing an element of variability into the precoating process.

During the service run the resin precoat shrinks as the ion exchange resin is exhausted. This shrinkage causes cracking of the precoat. The resultant precoat voids allow impurities either to pass to the filter demineralizer (F/D) effluent or become imbedded in the filter element. Precoat shrinkage can also cause the precoat to shift from depth to surface filtration.

Powdered precoat media can be volume reduced and disposed using a variety of options. The media can be vacuum compressed in a shipping liner, incinerated, thermally treated, and at one disposal site, very low activity media can be disposed directly on land without packaging. The chemistry of the fiber used in blends have been found to be a significant factor affecting biogassing in solid wet waste containers.

6.5.1.2 Septa

Stainless steel septa are historically the elements of choice for radwaste applications, however, the use of substitute poly based materials has rapidly grown acceptance in the industry. Stainless steel has the advantage of being able to be steam cleaned or washed with high pressure fluids with little or no resultant damage. Stainless steel is also less susceptible to oil fouling when compared to the new generation of advanced, slotted/pleated filter septa, however, the benefits associated with new, advanced septa materials and design discussed in the following section, typically outweigh the few benefits of stainless steel.

Pleated

Pleated elements provide significant filtration area increases, up to a factor of 20 when compared to radial surface area of a standard wrapped element of similar diameter and length. In using a pleated element the individual vessel flux can be reduced from close to 4.0 gpm/ft^2 to approximately 0.2 gpm/ft^2. When using pleated elements in precoat service, the filter elements can be used to remove the impurities and subsequently, the precoat needs to be porous enough to allow the corrosion products to pass to the membrane. Otherwise, the limiting factor to a dP endpoint will be surface filtration on the precoat layer.

In some cases, the amount of precoat material used on a pleated element has been reduced to roughly one-third of the wound element value. The fiber component of the precoat material has also been removed for pleated elements. In fact, the use of cellulose fiber in the precoat of these elements is suspected to reduce run lengths.

Membrane material for pleated elements to date have been polyester, polysulfone, polypropylene, and Kevlar.

Membrane filters can be operated as depth filters. The increased surface area of pleated elements when compared to wound elements allows for long cycle lengths. Finally, pleated filter elements offer the benefit of 100% thermoplastic materials of construction. These materials can be incinerated or shredded, increasing radwaste disposal options.

Resin Leakage

All powdered resin vessels equipped with a knife edge or single 'O'-ring seals on their elements leak resin. This is not a significant concern in most radwaste applications as the recycled liquid is typically reprocessed in the condensate polishing facility prior to introduction to feedwater systems. Additionally, the precoating process tends to seal leaks with the precoat material itself as the layer builds, however, any leakage path sealed in this manner will be vulnerable to future leakage during flow perturbations.

6.5.1.3 Operation

The majority of precoat filters are operated with a blend of fiber and ion exchange material, however, new membranes are typically being operated solely with ion exchange material. The filters are used for processing floor drain and equipment drain wastes. The effectiveness of the filtration is dependent on a large number of variables aside from the process stream characteristics.

Table 6-1 clearly portrays this using recent equipment drain precoat filter throughput data from ten plants.

Table 6-1 Comparison of Radwaste Equipment Drain Precoat Filter Media Performance

Station	Gallons Processed per Cu. ft. Media Expended
B-26, 500 Mw_e	12,000
B-19, 1100 Mw_e	19,400
B-5, 770 Mw_e	29,500
B-13, 1055 Mw_e	36,000
B-12, 1040 Mw_e	56,000
B-27, 1100 Mw_e,	56,400
B-6, 540 Mw_e	62,000
B-8, 760 Mw_e	64,400
B-11, 1030 Mw_e	70,000[A]
B-4, 760 Mw_e	157,000

B = BWR

NOTE A: This is a non precoat septa that achieves through-puts of 70,000 gallons between backwashes.

Several of the more important factors influencing filter performance are addressed in the following material.

Precoat Application

One of the more critical elements of successful precoat operation is the ability to create a precoat layer distributed evenly over the available surface area. Most plants precoat to the manufacturer's recommendation of 0.20 dry # per ft^2 of element surface area. Some plants operate at a higher precoat loading to increase ion exchange capacity. Others using newer elements operate with reduced precoat dosages. The maximum amount of precoat material that can be applied is based on the thickness of the precoat material as applied on the element and the element to element spacing within a particular vessel.

Exceeding this guidance can result in severe element damage if bridging occurs. Lower precoat loading is associated with a relatively new technology of minimum precoating.

Modified Precoat System

Industry experience indicates that if the resin/fiber mixture is deposited on the filter element over a very short period of time, the potential for uneven and/or cracking precoat layers increases. Typically, element inspections indicate uneven precoat application using the standard precoating process. This uneven/cracked precoat condition can allow passage of soluble impurities through the septa as well as allow insoluble impurities to penetrate the element material itself. This too, creates an increasing degree of element plugging (high clean dP). These phenomena will not only reduce system run lengths and lower effluent quality, but will also increase element replacement frequency.

Modified precoating employs a system capable of supplying precoat in a dilute, constant feed slurry.

EXAMPLE: The use of a precoat pump upgrade targeting increased precoat flux has been successful implemented. European experience with precoating at a higher flux has demonstrated increases in run length to a dP endpoint.

Bodyfeed

Bodyfeed is the process of slowly adding additional precoat material to the inlet side of a filter/demineralizer vessel during processing operations. A smaller initial precoat layer is applied to prevent element bridging. The additional precoat material acts to fill in cracks in the precoat or lightly precoated areas. This can extend filter run lengths.

Outages

During outage periods the filters are challenged by high volumes of reduced quality liquid waste inputs. This negatively impacts processing operations frequently resulting in reduced effluent quality for recycle or release. Additionally, processing low quality liquid wastes will result in more rapid filter fouling, increasing process related costs and waste disposal volumes.

The majority of precoat filters used in radwaste applications are operated to a predetermined dP endpoint. The filter dP directly impacts the performance of the filter modifying its ability to effectively process the waste stream at the design flow rate.

Backwash

Complete removal of spent precoat material is one of the major factors contributing to long element life and the ability for a filter/demineralizer system to continue to produce high quality effluent. An effective backwash is also important to maintain consistent run lengths as the elements age. The need to perform a backwash is determined by reaching a defined endpoint dP, or as a result of chemical breakthrough.

Hydro-pneumatic

The original hydro-pneumatic backwash was designed for fossil-fired systems. The quantity of backwash waste was not as much of an issue in the early filter/demineralizer systems as it is today. A normal hydro-pneumatic backwash uses 18 to 23 gallons of water per square foot of surface area.

Air volumes used in the backwash sequence were low, generally less than 1.0 standard cubic foot per minute (SCFM) per square foot of surface area.

Mod3

The Mod3 backwash was developed to reduce the backwash volume in BWR plants. Waste water volume per backwash was reduced to approximately 15 gallons/square foot of surface area.

The reduction in waste water volume was achieved by increasing the air scouring rate to 1.5 SCFM per square foot of surface area. The duration of the aeration steps were increased to take advantage of the increased scouring energy.
With Mod3, air and water are injected simultaneously into the vessel plenum while the upper filter chamber is vented. Water and air are injected simultaneously during all the cleaning steps and the level in the filter area is raised and lowered by cycling the vessel drain valve.

The effectiveness of this backwash method depends primarily on local turbulence produced when air escapes from the element just below the surface of the water. The water flow is used to carry the spent precoat material and corrosion products to a receiver tank.

Air Surge

The air surge modification was designed to extend element life by increasing backwash power using high energy, short duration bursts of air. It also significantly decreases the amount of waste water generated per backwash.

Initially the vessel is vented and drained. This draining step removes some of the precoat. A small flow of backwash water is applied to keep the vessel plenum filled. A fast acting valve allows a surge of air equivalent to 12 SCFM per square foot of surface area to enter the plenum area for approximately 2 seconds. The surge drives the water in the vessel plenum through the elements at high velocity. The standard backwash consists of eight surges. Maximum cleaning efficiency is achieved by using the drain valve to control the level in the filter chamber before each air surge.

Air Bump

The air bump backwash is prevalent in top tube sheet vessels. The air bump sequence starts with draining the vessel dome to the tube sheet level. Air is valved into the dome until it reaches the backwash air system pressure. A fast acting drain valve opens and the air pressure in the dome drives the water in the filter chamber out of the vessel. The drain valve opening speed is important in the overall efficiency of the air bump backwash. The faster the valve opening speed, the higher the overall energy of the backwash.

The air bump sequence is usually repeated for a total of 2 or 3 air bumps per backwash. The number of air bumps is kept to a minimum due to the need to fill the filter chamber for each air bump. This is required to pressurize the vessel dome. As a result, the number of repeats increases the amount of backwash waste water volume to be processed.

Following a backwash cycle, the clean dP is an indication of the effectiveness of the backwash process and the septa condition. An upward trend in the clean dP is indicative of less than desirable backwash performance, or irreversible septa fouling. This may require changes to the media specifications, procedures, hardware, or septa cleaning/replacement.

Backwash Waste Processing

While it is apparent that precoat filtration is effective, the process also produces a dual component waste stream. The backwash liquid and accompanying solids require additional processing prior to solids disposal.

Separation of these materials is typically accomplished in a phase separator or separate waste container, allowing solids to settle and decanting "clean" liquid for reprocessing and recycle or release. The iron oxide and other solids present in the waste stream is most effectively settled in slurries containing both resin and fiber precoat material. Minimum and non precoat filters generate less-to-no precoat, and solids settling efficiency is reduced. The effectiveness of the phase separation process is primarily dependent on retention time and the chemical attributes of the impurities present in the waste solution.

6.5.1.4 Operator Training

The quality of training provided to system operators can significantly impact the effectiveness and cost of precoat filtration. Inadequate training can result in inconsistencies with precoat application, backwash, effluent quality, radwaste generation, and overall system performance.

6.5.1.5 Septa Cleaning & Changeout

Septa cleaning is performed at several stations as a routine PM measure in an attempt to prolong septa life. The periodicity is determined by trending clean dP, or by using a predetermined time period based on historical performance (i.e., annually).

Chemical cleaning is usually not an option due to the potential for generation of a mixed waste. Steam cleaning or sludge lancing is sometimes used to restore the element's performance. Some plants have used, with mixed results, ultrasonic baths with a solution of muriatic or phosphoric acid to clean the elements, neutralizing the generated waste prior to treatment and/or disposal.

The changeout criteria for septa is typically based on a predetermined upper limit for clean dP. The waste septa radiation and activity levels vary by waste stream and unit and have corresponding variations in VR and disposal options. Most filter hardware is disposed rather than recycled in an effort to maintain personnel exposure ALARA.

As radwaste disposal costs increase, this practice is routinely being challenged. When handling waste septa, the use of remote or extension tooling similar to that recommended for cartridge and bag filters can be effective for maintaining associated personnel exposure ALARA.

6.5.1.6 Waste Packaging & Disposal

Similar to other processes, precoat filter waste's VR, packaging and disposal options are primarily controlled by the media or septa activity. Additionally, these program elements are impacted by:

- Plant structural and space constraints.
- Waste concentration averaging.
- Chemistry of waste.
- Available plant VR equipment.
- Disposal availability (long and short term).
- Disposal price structuring.
- Vendor services available for use.

Precoat media has several options for VR both on and off-site. The media can be compression packaged on-site in the shipping container resulting in VR ratios of up to 1.8:1 Additionally, some precoat waste qualifies for incineration, or may be eligible for alternate advanced VR technologies as they become commercially available such as the catalytic extraction process (CEP).

Waste septa can be compacted, supercompacted, shredded, chopped, or incinerated to decrease the waste volume or increase the waste density. The available options are dependent on septa dose rates and materials of construction.

6.5.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

6.5.2.1 Media Selection, Blending and Loading Logic

1. Use only premixed precoat products supplied by the manufacturer. These have been shown to provide increased throughput to a dP endpoint in most plants. The products are engineered by the suppliers to deliver the optimum floc for precoating of the filter elements. Proper floc size is an important parameter in ensuring a uniform precoat.

> **CAUTION:** Cellulose fiber has been linked to biogrowth problems. polyacrilonitrile (PAN) fiber can be used to minimize this problem, but PAN fiber is significantly more expensive than cellulose fiber.

2. Specifying a premixed resin containing various percentages of fiber. The addition of fiber helps reduce precoat cracking. In addition to preventing cracking of the precoat, fiber also helps remove organic impurities which may not be ion exchangeable.

3. Obtaining direct technical support from the material supplier to evaluate and recommend precoat process improvements.

4. Evaluate the material relative to VR and disposal options.

6.5.2.2 Septa

1. When using pleated elements in precoat service, the precoat needs to be porous enough to allow the corrosion products to pass to the pleated filter membrane. Otherwise, the limiting factor to a dP endpoint will be surface filtration on the precoat layer.

2. The pleated element precoat volume should be reduced to roughly one-third of the wound element value. The fiber component of the precoat material should also be removed for pleated elements.

3. Carefully evaluate the pore size selected for membrane materials. If the pore size of the membrane is too close to the size of the corrosion product being removed, the chance of imbedding corrosion products in the membrane pores exists. If the pore size of the membrane is too large, the corrosion product removal efficiency would be less than expected

4. Installation of innovative new tube sheet adapters for both top and bottom tube sheets that can eliminate resin leakage at the tube sheet to element interface.

5. Another hardware variation is a fixed core design. A 100% thermoplastic element can then be slipped over the fixed core to maintain structural integrity. The thermoplastic element can be incinerated or shredded for VR at the end of the element's useful life.

6. For top tube sheet installations, a double 'O' ring attachment has gained acceptance. In this configuration, double 'O' rings provide a positive seal and allow the filter to be constructed from 100% thermoplastics however, a new tube sheet and support grid may be required. As a result, spent filters can be incinerated or shredded for VR using this improvement.

6.5.2.3 Operation

1. Use a modified precoat system in conjunction with existing precoat equipment, a uniform precoat can be applied over the entire element surface area, thus

reducing the potential for precoat cracking and element fouling. This technique results in longer process run lengths, increased element life, less variability in performance, and improved effluent quality.

2. If bodyfeed equipment is installed and not currently used, re-evaluate its use to maintain the precoat in a depth filtration mode for a longer period of time, extending the media run length.

6.5.2.4 Operator Training

1. The overall precoat process should be reviewed and analyzed. Based on that analysis, develop hands on training for operators, engineers and maintenance personnel to enhance process performance.

2. Utilize a pilot ***scale*** filter/demineralizer unit for conducting operator training. The scale unit should allow visual observations of the precoat and backwash processes. This would not only be a valuable training tool, it could also serve as a test facility for alternative precoat media, techniques and technology—making the tool invaluable for enhancing any F/D's performance.

3. Provide fundamental chemistry training to operators to enhance their understanding of the importance of proper component operation.

6.5.2.5 Septa Cleaning & Changeout

1. Evaluate the use and effectiveness of steam cleaning or hydrolasing septa on a routine basis based on clean dP trends, or historical performance data.

2. Carefully comparing waste disposal, septa changeout and associated labor costs with ALARA "costs", ensuring ALARA based changeout decisions are cost effective.

> **NOTE:** "Clean" filter differential pressure (dP) profiles should be established and not exceeded. Precoat, non precoat and minimum precoat filter/demineralizers are particularly susceptible to irreversible fouling that can result in elevated dose rates and increased personnel exposure.

3. Incorporating the use of remote and extension tooling, and shielded transfer bells in septa changeout evolutions as required by activity levels. Septa changeout can sometimes be performed semi-remotely for top tube sheet vessels. The bundle can be lifted from the service vessel and placed in a shielded container for decay. Depending on the type of element attachment mechanism, the elements can be loosened using long-reach tools.

4. Several stations have developed unique transfer mechanisms such as a vacuum assisted housing to waste liner transfer tube, or carousel transfer containers. The use of video equipment is also frequently used for remote radiation protection monitoring and evolution recording for future task analysis and enhancement.

5. When establishing septa changeout criteria include ***VR and disposal options*** in the analysis. Lower activity septa can be effectively volume reduced and density increased to create an optimum waste form for cost effective disposal.

6. When establishing septa changeout criteria, include the impact of ***waste classification and disposal costs*** in the analysis. Increasing the septa activity through extended service without VR will increase disposal costs, therefore it ***may*** be more cost effective to perform septa changeout on a more frequent basis.

6.5.2.6 Waste Packaging & Disposal

CAUTION 1: Ensure changes to packaging strategies remain in compliance with the PCP, and container C of C and procedures.

CAUTION 2: The bottom dewatering laterals on powdered resin liners can be dependent on capillary action. To ensure compliance with disposal site residual liquid criteria, it may be prudent to load a bead resin bottom layer first, acting as a buffer to preclude clogging the dewatering laterals.

1. Evaluate all options for VR and disposal including in-container VR, shredding/chopping, compaction, incineration and CEP.

2. Similar to the impact on alternate wastes, analyze the site structural layout to ensure media and septa VR, packaging and transport preparation evolutions are optimized.

3. Analyze the disposal fee structure to define the most cost effective precoat media and septa packaging density and activity. As part of that analysis

include density and activity changes on transportation fees and packaging and disposal options.

When evaluating packaging requirements, include the following:

- Container material, size, cost.
- Stabilization requirements.
- Density impact.
- VR and packaging efficiency.
- Curie content.
- Dose rate.
- Packaging equipment requirements.

6.5.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI product "waste***WORKS:***Wet Computer Code".
4. The EPRI document titled "Cost-Effective Liquid Processing Programs".
5. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
6. The EPRI document titled "Proceedings; Second Workshop on Condensate Polishing with Powdered Resin".
7. An industry document titled "Reactor Water Cleanup Systems, a Comprehensive Summary of Design, Corrective Actions and Improvements".
8. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".
9. An industry paper titled "Relevance of Silica in Fuel Pool Purification".
10. The EPRI document titled "Analyzing Advanced Liquid Waste Minimization Techniques at a PWR: Advanced Media, Pleated Filters, and Economic Evaluation Tools".
11. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

6.6 Program Element: Non Precoat

6.6.1 Program Impact

Precoat elements are used extensively in BWR stations for processing high quality, high activity equipment drain waste and low quality, low activity floor drain wastes. The majority of the waste generated using this method of liquid processing is media changed out due to high dP or ion exchange performance degradation.

For systems that are configured with a precoat filter/demineralizer followed by a deep bed demineralizer, the potential exists for changing the filter technology from precoated septa to non precoat elements. The use of this advanced technology has been successfully demonstrated and can result in a significant savings to the utility without compromising overall system performance. However, prior to implementation and to ensure continued satisfactory performance during operation, the following issues should be adequately addressed.

6.6.1.1 Selection and Loading Logic

Recent experience with non precoat elements in floor drain, equipment drain and condensate applications has produced a large volume of pertinent information. To date, the use of this technology in low quality process waste streams has resulted in less than desirable results. However, properly implemented applications in higher purity streams such as equipment drains and condensate have proven to be successful and cost effective.

Similar to cartridge filtration or precoat septa selection, a thorough knowledge of the liquid to be processed and the end use of the system effluent are critical elements of septa selection. The success of non precoat filtration is highly dependent on a careful evaluation of particle sizes and distribution. Additionally, this technology offers the opportunity to significantly increase the total filter surface area, resulting in a highly desirable flux reduction.

Manufacturer support during the waste stream analysis, septa design and initial operation can result in more successful implementation of this technology. This support is critical when determining construction material compatibility with the application, micron rating, and when performing the filter flux and backwash analysis.

6.6.1.2 Operation

Non precoat filters are very susceptible to failure when exposed to poor quality inputs (e.g., organics, particulate). Therefore, water management practices should be incorporated into processing strategies to minimize low quality inputs.

By design, non precoat filters are not ion exchangers and are therefore operated to a predetermined dP endpoint versus chemical breakthrough. The filter dP directly impacts the performance of the filter modifying its ability to effectively process the waste stream at the design flow rate. Industry experience indicates that the filters should not be operated to the design upper dP, but that a lower, more conservative value should be used. This technique improves the effectiveness of backwashes, and helps delay irreversible septa fouling, increasing its useful life.

Another unique aspect of non precoat filter operation is related to backwash waste processing. The lack of fiber or ion exchange media greatly reduces the solid waste volume, but has negatively impacted the rate and quality of solids separation in phase settling tanks. The use of extended settling periods or the addition of chemical flocculants or polymers has been used to enhance this process.

6.6.1.3 Septa Changeout

Based on limited experience with non precoat elements, the changeout criteria has been based on a clean dP upper limit. The waste septa radiation and activity levels vary by waste stream and unit resulting in variations in VR and disposal options. When handling waste septa, the use of remote or extension tooling similar to that recommended for precoat septa, cartridge or bag filters can be effective for maintaining associated personnel exposure ALARA.

6.6.1.4 Waste Packaging & Disposal

Waste generated as a result of non precoat septa use can be volume reduced and disposed using options primarily governed by the septa activity and packaging limitations.

Additional factors influencing VR and disposal include:

- Plant structural and space constraints.
- Waste concentration averaging.
- Available plant VR equipment.
- Disposal availability (long and short term).
- Disposal price structuring.
- Vendor services available for use.

Waste septa density can be manipulated or its volume reduced through compaction, supercompaction, shredding, chopping, or incineration. The available options are based on septa activity, corresponding dose rates and materials of construction.

6.6.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

6.6.2.1 Selection and Loading Logic

CAUTION:	The station should carefully review FSAR, Licensing documents and safe shutdown requirements prior to altering septa configurations to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

1. The waste stream characterization and filter analysis described previously in Sections 6.1 and 6.2 should be completed prior to filter specification. Actual plant experience with non precoat septa indicates that several critical issues must be addressed for successful performance. They are:

   - An accurate analysis of the particle size distribution and loading. The particle size rating of the filter must be smaller than that of the liquid stream to be processed. Particles equal in size to the filter pores can result in particles being "wedged" in the membrane structure. These particles may not be removed during backwash cycles.

   - Filter septa flow characteristics and flux.
     Non-precoat elements generally are operated to a lower dP than precoated counterparts. The added surface area reduces the backwash energy per unit area and the lower terminal dP precludes driving the removed particulates into the membrane surface. The added surface area of a pleated non-precoat element results in a much lower operating flux.

   - Vessel nozzle size, and backwash pressure and flow profiles should be evaluated. The drain lines for backflushes must be adequately sized to permit a rapid depressurization of the vessel during backwashes. The membranes require a significant shock for efficient crud removal from the filter.

- Vessel flow and pressure characteristics should be evaluated to ensure adequate flow rates and system pressures can be maintained during normal operations.

2. The use of testing on a pilot unit is recommended prior to installation, to optimize filter performance.

6.6.2.2 Operation

1. Identify and analyze expected fluctuations in the process waste stream characteristics. As part of that evaluation consider the impact of inputs rerouted from other process systems as well as outage liquid waste generation and its associated influent quality degradation.

2. Establish methods to preclude influent quality variations or degradation to the extent practical through procedural controls, equipment line-up reconfiguration or the use of alternates to processing.

3. Trend filter dP to effectively monitor performance.

4. Monitor the filter doserate buildup over filter life.

5. Increasing the time allotted for phase separation or enhancing the settling process through the use of chemical additives.

6.6.2.3 Septa Cleaning & Changeout

1. Developing a correlation between the dose rate on the external surface of filter vessels and actual non precoat septa activity levels. Use this data to develop limits for changeout to maintain exposure ALARA. The analysis should also reflect filter dP, septa changeout costs, VR, disposal and associated labor while remaining cost effective.

> **NOTE:** "Clean" filter differential pressure (dP) profiles should be established and not exceeded. Precoat, non precoat and minimum precoat filter/demineralizers are particularly susceptible to irreversible fouling that can result in elevated dose rates and increased personnel exposure.

2. Establish a conservative upper clean dP limit to be used as an evaluation point for septa cleaning or replacement.

6.6.2.4 Waste Packaging & Disposal

CAUTION:	Ensure changes to packaging strategies remain in compliance with the PCP, and container C of C and procedures.

1. Evaluate all options for VR and disposal including shredding, chopping, compaction, and incineration.

2. Review site imposed activity restrictions relative to non precoat septa dose rate, VR and disposal. Where applicable, adjust operational limits to ensure disposal costs are minimized.

3. Similar to the impact on alternate wastes, analyze the site structural layout to ensure septa VR, packaging and transport preparation evolutions are optimized.

4. Consider holding waste containers for decay prior to shipment.

5. Analyze the disposal fee structure to define the most cost effective packaging density and activity. As part of that analysis include density and activity changes on transportation fees and packaging and disposal options.

   When evaluating packaging requirements, include the following:

   - Container material, size, cost.
   - Stabilization requirements.
   - Density impact.
   - Dose rate.
   - Curie content.
   - VR and packaging efficiency.
   - Packaging equipment requirements.

6.6.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI product "waste*WORKS*:Wet Computer Code".
2. The EPRI document titled "Cost-Effective Liquid Processing Programs".
3. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
4. The EPRI document titled "Proceedings; Second Workshop on Condensate Polishing with Powdered Resin".

5. An industry paper titled "A Case Study of the use of Non-Precoat Filters in BWR Condensate Polishing: Full Unit Results".
6. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
7. The EPRI document titled "Analyzing Advanced Liquid Waste Minimization Techniques at a PWR: Advanced Media, Pleated Filters, and Economic Evaluation Tools".

6.7 Program Element: Carbon

6.7.1 Program Impact

Historically, activated carbon media has primarily been used for LRW system prefiltration in pressurized water reactors (PWR). This treatment continues to be effective for organics and solids removal, providing protection for follow-on demineralizers and advanced filtration technology. Recently, the use of polymers has enhanced the applicability of carbon for cobalt and other specific isotope's removal. However, because this is typically a lead bed in any processing configuration, it has the potential to rapidly become fouled or depleted, generating a solid radwaste.

Several vessel designs incorporate a high energy backwash or top sluice feature. This technique results in a slurry requiring phase separation and decant, potentially introducing a volume of concentrated chemical and solid impurities into the radwaste processing system.

6.7.1.1 Selection and Loading Logic

Activated granular carbon is graded by mesh size. Selection of the appropriate mesh size is highly dependent on the characteristics of the influent waste stream and downstream processes. The material can be effectively used as depth filtration by layering the bed with various mesh sizes, such as a coarse-fine-coarse configuration. This practice is intended to extend the media throughput and more effectively remove various particle sizes using a single vessel. Several utilities operate with variations of the processing technique using coconut based media with varying results.

The media selection analysis should also take into consideration handling, packaging and disposition of the resultant solid waste. Equally important in the selection analysis is consideration of vessel design, location and shielding to support normal operations and maintenance.

6.7.1.2 Operation

When used in a lead filtration mode, the carbon performance will degrade with throughput, primarily as a result of particulate loading and biogrowth. There are four options for restoring performance:

1. High energy backwash.
2. Top sweep – crud removal, minimal carbon removal.
3. Top sluicing and reloading several cubic feet of media.
4. Total bed sluice and reload.

> **CAUTION:** Vessels with carbon media layered by mesh size should not be backwashed. This process can result in elimination of layers, creating a more homogenous mixture.

Vessel design may preclude top sweeping or sluicing, and a high energy backwash will result in a waste stream with a high concentration of solids requiring additional treatment. This waste stream (a significant source of biogassing nutrients) can be routed to a HIC containing waste ion exchange or carbon media to permit phase separation and decant of a higher quality liquid stream for normal radwaste processing methods. Top sluicing the vessel generates a slurry that is sluiced to a disposal liner for normal solid waste processing. This technique results in removal of the highest particulate waste concentration present in the processing vessel, restoring performance to near normal values, and generates minimal solid waste

Experience has shown that the backwash and top sluice are most effective if the vessels are not loaded to maximum design capacity. Instead, they are "short" loaded leaving sufficient space at the top of the vessel to accommodate adequate agitation to effectively remove the solids and/or media during the evolution. Pre-charge testing to verify expected performance or a pre-operational rinse to remove carbon fines generated during shipping and loading can alleviate concerns related to fines forwarding to follow-on beds. An effluent sample prior to placing the media in service can be used to verify media quality.

The considerations for backwashing the vessel are similar to filter/demineralizer septa. The backwash is most effective if the vessel is shocked by a high energy wash and rapidly depressurized, maximizing internal agitation of the waste solids and carbon media.

6.7.1.3 Changeout

Carbon vessels are typically operated to a predetermined dP endpoint, minimum flow rate, activity or DF. At that time, the vessel is backwashed, top sluiced or a full changeout is performed to re-establish the desired performance.

Many factors influence the course of action selected including the following:

- Vessel design and inclusion of backwash or top sluice capabilities.
- Media type and period of service.
- "Clean" dP - the ability to adequately restore performance without changeout.
- Carbon loading strategy.
- Downstream processes.
- Desired performance (i.e., recycle versus release)
- Waste disposal options and costs.
- Outage planning considerations.
- Waste classification versus changeout criteria.
- ALARA considerations.

Any of the four performance restoration options will result in generating a low quality, potentially higher activity waste stream that requires additional treatment prior to recycle or release. The waste solids are normally transferred directly to a transportation liner for shipment to VR facilities or directly for disposal.

> **NOTE:** High concentrations of polymers, lubricants and other chemical additives in the vessel can result in difficult to sluice media.

6.7.1.4 Waste Packaging & Disposal

Carbon waste is normally packaged in liners or HICs and either volume reduced through incineration or directly disposed. Similar to other waste streams, the primary factor for determining immediate disposition is the waste activity. Media that is < 200 mR/hr on contact with the package can typically be incinerated prior to disposal. This does result in a VR, however the current disposal site pricing structure can impact the cost effectiveness of this process.

In a few instances, low activity carbon can be used as overfill for other solid waste containers to optimize the packaging efficiency, waste density, or activity, without incurring additional disposal costs.

6.7.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

6.7.2.1 Selection and Loading Logic

1. Carefully analyze influent characteristics and anticipated perturbations IAW the previous sections.

2. Obtaining supplemental technical support from the product manufacturer for guidance related to optimum media type and loading configuration. The use of the data gained during the waste stream characterization should be incorporated into this evaluation.

3. Identify required internal and external vessel hardware to accommodate top sweeping, backwashes, top and bottom sluice operations, and the appropriate site interfaces to support those evolutions. The vessel should be designed for the "range" of carbon mesh sizes to be used to prevent fouling internal retention laterals. Additionally, the vessel design should include internal rinse capabilities and be adequately constructed to minimize the potential for premature failure of internal hardware as a result of high energy backwash and sluice operations or microbiologically induced corrosion (MIC).

4. When evaluating the vessel location consider:

    - Valving.
    - Instrumentation.
    - Hoses.
    - Personnel access for operation and maintenance.
    - Shielding.

5. Use scaled down processing columns for testing media types and configurations prior to full scale implementation. This test equipment could also be used for future evaluation of proposed system processing improvements.

6.7.2.2 Operation

> **CAUTION 1:** The station should carefully review FSAR, Licensing documents and release permits prior to using process alternatives to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

> **CAUTION 2:** When practical, installed plant resin vessels designated for carbon processing should not be bottom loaded with carbon media. This may result in fouling retention laterals. A short charge of bead resin can be used to act as an interface between the carbon and laterals, minimizing fouling. In some cases this practice may also improve the performance for vessels specifically designed for carbon media.

1. Coarse grade carbon should normally be loaded on the top of the charge and at least medium grade media used on the bottom. The coarse will minimize premature fouling of the fine carbon and the medium to coarse on the bottom will preclude fouling effluent retention elements.

2. The vessel should be short loaded (to less than the recommended maximum media charge volume) to ensure agitation during backwash and sluice operations is adequate. Additionally, a full charge may not be required for the system operational characteristics such as flow rate, retention time, etc.

3. Perform a pre-service rinse and analysis to verify media quality prior to use. This simple evolution can provide an additional protective measure for downstream demineralizers.

4. Similar to ion exchangers, the DF across the vessel should be determined and evaluated on a routine basis.

   At a minimum these data should be obtained as follows:

   - **System influent** - prior to process system startup, facilitating appropriate configuration changes based on identified impurities.

- **System effluent** - as soon as possible following at least one system volume turnover. Maximum within one hour of process startup to verify satisfactory performance.
- **Individual component or vessel performance** - weekly or as appropriate based on overall system performance and influent quality.
- **Following any known system or influent transients** - influent and effluent samples - immediately.

6.7.2.3 Changeout

1. Incorporating a top sluice capability in retrofit vessel's design specifications, or when modifying existing vessels, to permit removal and replacement of media.

2. The backwash waste slurry should be treated as a separate waste stream either in a designated liner containing waste resin or carbon media, or in a retention tank that can be effectively decanted and desludged. Introduction of backwash waste to a normal liquid waste processing configuration would result in a severe challenge to processing media and components generating additional solid waste.

3. Verifying through radiation surveys or visual inspections that top sluice, backwash, or total bed sluices are effective and that minimal residual solids remain on vessel interior surfaces. Rinsing, sparging or opening access ports for manual high pressure cleaning following these evolutions can effectively reduce the immediate challenge to replacement media.

4. Perform a media rinse prior to loading to remove fines generated as a result of shipping and on-site handling. A second, less desirable option is to perform the rinse following media loading, prior to service.

6.7.2.4 Waste Packaging & Disposal

> **CAUTION 1:** Ensure changes to packaging strategies remain in compliance with the PCP, and container C of C and procedures.

> **CAUTION 2:** The bottom dewatering laterals on resin liners can be dependent on capillary action. To ensure compliance with disposal site residual liquid criteria, it may be prudent to load a bead resin bottom layer first, acting as a buffer to preclude clogging the dewatering laterals with carbon fines and other solids.

1. Similar to the impact on alternate wastes, analyze the site structural layout to ensure carbon VR, packaging and transport preparation evolutions are optimized.

2. Analyze the disposal fee structure to define the most cost effective packaging density and activity. As part of that analysis include density and activity changes on transportation fees and packaging and disposal options.

   When evaluating packaging requirements, include the following:

   - Container material, size, cost.
   - Density impact.
   - Dose rate.
   - Curie content.
   - VR and packaging efficiency.
   - Packaging equipment requirements.

3. Evaluate activity based, direct on-land disposal off-site. Dewatered low activity carbon is disposed in separate landfill cells. This type of disposal is a "cut-and-cover" process with the waste material being deposited in twelve inch layers and then compacted. After the cell capacity is reached, the waste is entombed in a seven-foot thick clay radon barrier, with a rock erosion barrier on top.

6.7.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".
3. The EPRI document titled "Spent Resin Disposition-Available Alternatives and Selection Analysis".

6.8 Program Element: Deep Bed Demineralizers

6.8.1 Program Impact

Demineralizers have the primary function in LRW applications of removing ionic impurities, and in some cases insoluble metals (corrosion products). Demineralizers are efficient for removing ionic impurities. It is important to note that improperly operated demineralizer systems can actually add impurities to the system effluent negatively impacting liquid release or recycle efforts.

Deep bed ion exchange resins remove insoluble products both by mechanical filtration and electrostatical attraction. Filtration is accomplished by trapping particulates in "pinch points" located between the resin beads. Smaller resin particle sizes will increase the number of those points (filtration efficiency) at a cost of increased dP. Bead resin can also act as a depth filter.

Over the past decade, LRW demineralization experience and resin management improvements have resulted in a significant reduction in generated waste resin volumes. Solid waste volumes continue to decline with advances in the areas of filtration, membrane and resin/media manufacture.

However, increased regulatory and vendor requirements related to waste packaging, volume reduction, transportation and disposal require continued evaluation of demineralization processes.

6.8.1.1 Selection, Blending and Loading Logic

CAUTION:	The station should carefully review FSAR and Licensing documents prior to using alternate media loading strategies to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

There are two types of whole bead ion exchange resins typically used for LRW demineralizers, strong acid cation and strong base anion resins. Deep bed resins are typically styrene divinylbenzene (SDVB) copolymers. These resins are given the name "gel-type". The degree of divinylbenzene crosslinkage gives the resin properties of strength and stability (resistance to oxidation).

Ion exchange resin is organic in construction. Therefore, as oxidation of resin occurs, organic impurities can be introduced to the system if the anion resin doesn't remove it. For process and release, this is probably an insignificant issue.

However, for reactor water recycle applications, resin fines are broken down in the neutron flux and temperature of the reactor to carbon dioxide, weak organic acids, and the acid form of the functional groups associated with the resin type, cation or anion.

Ion exchange resin design performance is predicated by system inlet characteristics. As such, the waste stream characteristics and fluctuations impact the resin's performance. The expense associated with more costly custom or advanced media applications, should be commensurate with the desired effluent results.

Mixed bed resin from suppliers should be used only if it is within the shelf life specified by the manufacturer. Cation resin generally has a shelf life of 1 year from manufacture. Anion resin generally has a shelf life of 6 months from manufacture (conversion).

The stoichiometric mix, or ratio of anion to cation resin in a mixed bed, can directly impact the generated volume of solid radwaste. The stoichiometric mix used should be based on the relative concentration of anion and cation impurities to be removed from the influent waste stream. An improper mix can result in anion depletion prior to cation depletion (particularly true for atmospheric or aerated systems), or vice-versa. Traditionally, a 60-40 anion to cation ratio has been used. Through experience, many plants utilizing mixed beds have modified the ratio to closer to a 40-60 anion-to-cation blend. For some radwaste applications, this results in a higher media throughput prior to chemical or radioisotope break.

For plants that use a chemically equivalent (stoichiometric) mix of anion and cation media, the resins must be properly sized in order to prevent separation during transfers and/or vessel fills. If the resin separates, it is difficult to achieve desired effluent water quality.

If the liquid treated is t o be recycled, a mixed bed is selected. These beds must provide water purification and remove nuclides. Break through of chloride, fluoride, sulfate, nuclides, silica and pH are criteria for changeout of mixed beds.

Some plants use a chemically equivalent (stoichiometric) mix of anion and cation resin for mixed bed applications. In this application, the resin beads must be properly sized in order to prevent separation during resin transfers and/or vessel fills. If the resin separates, it is difficult to achieve the desired effluent water quality for recycle.

If the liquid treated is to be discharged, ion exchange selection can be based solely upon the remove of radionuclides. By removing only radionuclides spent media generation can be reduced without adversely impacting effluent activity. In general, cobalt, nickel, iron, cesium, iodine and antimony are prominent nuclides in effluent. Antimony has a low effluent dose impact when compared to other nuclides.

Organic cation resin will remove soluble species of cobalt, nickel, iron and cesium. Historically, hydrogen form cation resin has been used for this service. The use of sodium form cation resin in concert with influent pH adjustment has demonstrated increased throughputs.

Cesium will generally be the first soluble nuclide to break through an organic cation bed. Cesium is a nuclide with a high effluent dose impact. If cation resin throughput is limited by cesium break, the use of cesium selective media should be considered.

Inorganic zealots (e.g., chabazyte, clinoptilolyte) have been shown to be highly selective in removing cesium from liquids with conductivitys less than 2,000 μmho/cm. These materials have demonstrated a higher capacity for selective ion removal. Zealots have been used for LRW treatment by both spiking organic beds with a few cubic feet of material and by separate beds containing only zeolite. Synthetic and natural zealots have demonstrated improved throughput when compared to organic resins.

Many other cesium selective media are available. They are all organic, and their use should be considered for influent liquids with conductivitys higher than zealots are capable of effectively treating.

CAUTION 1: The corrosion impact of a heavy inorganic media on the spent media transfer piping must be considered prior to use.

CAUTION 2: The ability to package the spent inorganic media in compliance with disposal site criteria and HIC C of Cs commingled with resin and/or carbon must also be evaluated prior to use.

Organic anion resin is very selective for iodine removal. Anion resin will also remove some forms of soluble cobalt. Antimony is removed by anion resin, but has a low affinity for it. Shifts in influent pH can release antimony collected on an anion bed. Anion resin has a higher affinity for boron than antimony. In borated liquid processing scenarios, the demineralizer effluent antimony may exceed the influent.

For plants with only one deep bed vessel processing for discharge, a mixed bed should be used. Altering the cation to anion ratio can extend the life of such mixed beds. Cation to anion rations of 4:1 up to 9:1 have been reported to provide suitable effluent and increased bed life. Altered cation to anion ratios equate to predicting the ionic nuclide makeup of influent liquids. The consistency of influent liquids will dictate the extent and the success of altered resin ratios.

The use of segregated ion exchange beds with a different media in each bed has been adopted by many plants processing for discharge. By separating the media into different vessels, each media type can be used to depletion. No media must be disposed of prematurely due to the exhaustion of other media in the same vessel. By separating the media into different vessels, predicting the makeup of influent liquid is not as critical.

6.8.1.2 Operation

The primary objective of demineralizer operation is to achieve the desired effluent quality with minimal radwaste generation in a cost effective manner. In order to attain these goals, the operator must have a thorough understanding of the media, demineralizer system and its operation.

Waste stream characteristic stabilization can aide in achieving this goal. The treated waste stream characteristics and potential fluctuations can dramatically impact media performance. Low quality influent can rapidly foul, or deplete ion exchange media. Resin that is improperly loaded, rinsed or "fluffed" can result in fractured beads, effluent chemistry fluctuations and destruction of chromatographic bands. These deviations all negatively impact media performance.

Some stations have the ability to align demineralizers in various series and parallel configurations. This allows the operator to establish custom line-ups, tailoring the process to accommodate influent LRW and to achieve the desired effluent quality.

EXAMPLE: At many stations, partially depleted condensate polisher or SGBD processing media is transferred to the radwaste system deep bed for further ion exchange utilization. This practice has the benefit of using a majority of the resin capacity. Normally, individual vessel and system dP is monitored to evaluate solids loading, influent characterization changes and prefiltration adequacy.

Using the isotopic composition of the influent LRW or historical spent media data, and the media type in service, a correlation can be developed between the dose rate on the vessel external and the approximate media curie content and dose rate. This is useful when establishing activity limitations related to volume reduction options, personnel exposure and disposal costs.

Anion resin tends to become fouled with organics from cation resin breakdown (de-crosslinking/oxidation), hydraulic fluids and iron. Anion resin is more susceptible to kinetic impairment than cation resin. When resin kinetics are lost, the resin will lose its salt-splitting capacity and anions will pass through to the LRW system effluent.

Strong acid cation resin has a maximum operating temperature limitation of 250 F. Strong base anion resin has an upper temperature limit of 140 F. High temperatures cause the quaternary ammonium functional group to convert to the tertiary amine group (or become weak base), losing salt splitting capacity.

6.8.1.3 Changeout

Domestic plants use data such as dP limitations, media activity, chemistry/activity breakthrough, or total processing throughput to develop changeout criteria.

Increasing the throughput may result in an increase in resin activity and therefore waste classification. Defining changeout criteria (i.e., dP, throughput, DF, activity, dose) requires careful analysis of the desired effluent for individual beds. It also requires an analysis of the costs associated with spent resin packaging, transport, VR and disposal. The incorporation of ALARA considerations related to system operation, and changeout planning and scheduling is prudent.

However, restrictive limitations may be off-set by increased resin procurement and disposal costs.

EXAMPLE:	Several stations have determined that more frequent media changeout in an effort to minimize personnel exposure, has actually resulted in increased exposure related to the more frequent packaging and disposal operations.

When performing a resin sluice/transfer, the use of shielded transfer lines will minimize personnel exposure. Maintaining the spent resin slurry in a "soup-like" consistency will help to ensure transfer lines do not clog, eliminating additional effort that could result in increased personnel exposure and liquid waste volumes.

6.8.1.4 Waste Packaging & Disposal

Waste bead resin is normally packaged in liners or HICs and either volume reduced through incineration, catalytic extraction process (CEP) or directly disposed. Similar to other waste streams, the primary factor for determining immediate disposition is the waste activity. Media that is < 200 mR/hr on contact with the package can typically be incinerated prior to disposal. This does result in a VR, however the current disposal site pricing structure can impact the cost effectiveness of this process. In some instances, very low activity resin can be disposed using direct on land disposal at an authorized disposal site. It can also be used as overfill for other solid waste containers to optimize the packaging efficiency, waste density, or activity.

Additionally, spent resin packaging, VR and disposition options are impacted by:

- Plant structural and space constraints.
- Waste resin blending and concentration averaging.
- Dewatering equipment.
- Disposal availability (long and short term).
- Disposal price structuring.
- Vendor services available for use.

6.8.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

6.8.2.1 Selection, Blending and Loading Logic

> **CAUTION:** Prior to using partially depleted low activity media from other plant systems, the station should evaluate the cost factors including:
>
> - The remaining capacity versus disposal as low activity resin.
> - Disposal costs for depleted resin following activity increase associated with LRW processing.
> - New resin procurement and warehousing.
> - Labor, containers and storage of partially depleted media waiting LRW use.
> - Solids/particulate loading (iron) of the reused resin.

1. Radioactive ion exchange media selection for recycle.

    - Determine the reason for mixed bed replacement. Is cation capacity depletion the cause for bed replacement or anion capacity? Does the reason for replacement change from one bed to the next?
    - If the cause for bed replacement is consistent, consider altering the ratio of cation to anion as appropriate.
    - Consider an alternate supplier of mixed bed resin. Organic resin from one vendor may have higher capacity for soluble species than what is currently in use.
    - Consider the use of partially depleted condensate polishing or SGBD resin for LRW processing.

2. Radioactive ion exchange media selection for release.

    - If only a single vessel is available, consider increasing the cation to anion loading (e.g., 4:1or more) to increase bed throughput.
    - Determine is cation throughput and performance is acceptable. If it is not, consider the use of an alternate, isotope specific media for processing low conductivity inputs.
    - If influent conductivity is high and cesium effluent is a concern, consider the use of inorganic cesium selective media.
    - If multiple vessels are available, consider segregated loading of ion exchange media to preclude premature media depletion. As part of that evaluation, consider release permit requirements, cost effectiveness and the impact on operator attention.

- Evaluate the use of isotope specific media to resolve plant specific issues.

3. For borated LRW processing, consider pre-borating LRW beds prior to placing in service to preclude antimony "throw/sloughing".

4. The use of partially depleted condensate and SGBD resins for LRW processing can maximize that resin's usefulness while simultaneously minimizing new resin procurement costs.

5. Ensure the procurement specification stipulates sifting for particle size and that organic chemicals are fully rinsed from the resin. Establish a manufacturer's limit for the percentage of acceptable fines. There have been instances where resin impurities and fines have caused reactor coolant chemistry excursions.

6. Evaluating all goals that impact resin selection and change-out criteria. Include the following in the analysis:

   - Personnel exposure
   - Resin procurement
   - Throughput
   - Waste packaging and disposal classification.
   - Outage planning considerations.

7. Plan and document the criteria for resin selection based on known plant evolutions.

8. Following process stream characterization, develop separate detailed specifications for each resin application. Ensure that the resin type/blend is commensurate with the intended function. The waste stream characterization, processing system goals, and process flow rate should be used to select a resin for the desired performance. Avoid the use of a single generic media design for different waste streams for the sole purpose of streamlining the procurement and on-site warehousing process.

9. Anticipated waste stream characteristic fluctuations should be considered when specifying resin. Known fluctuations or expected perturbations based on planned and projected plant evolutions should be analyzed for impact on media performance.

10. Evaluate the resin procurement and disposal cost versus application in the system. Utilize custom blend or isotope specific media only when it is cost effective or required to meet release criteria. Use "off the shelf" media whenever possible to minimize processing costs.

11. Consider an alternate supplier of resin. Organic resin from one vendor may have a higher capacity for soluble species than what is currently in use.

12. For mixed beds, minimize water volume in vessels during resin loading to prevent hydraulic separation.

13. The use of a water buffer in the vessel prior to loading, may minimize bead fracture during the loading process.

14. Procedures and operational practices for layering carbon with ion exchange media should be evaluated to ensure the differing media densities are taken into account when charging vessels. Differing medias in a fully immersed bed may separate due to density differences altering the desired end result. Additionally, backwashing layered beds to remove or redistribute solids deposits, will disrupt the layers as well as the resin chromatographic bands, negatively impacting the process.

15. When specifying replacement or add-on demineralizer ***vessels***, the specifications should address minimization of MIC, include a specific rinse header, flow distribution plate/baffles and retention screens sized for the specific media application.

16. Ideally, site batched mixed bed resin should be used immediately following mixing. If the cation resin to be used exceeds the shelf life, it should be rinsed separately to remove leachable organics prior to mixing with anion resin.

17. If cation resins are not used in a one year time frame, each resin lot should be sampled for capacity and leachable organic concentration. If the capacity has not degraded to less than new resin specification limitations, the shelf life can be extended another six months.

18. If anion resins are not used in a six month time frame, each resin lot should be sampled for capacity and leachable organic concentration. If the capacity has not degraded to less than new resin specification limitations, the shelf life can be extended another six months.

19. The information in recommendations 12, 13, 14 and 15 should be used to analyze the impact of reduced media capacity, that media's use and the potential that use increasing solid waste disposal volumes and program costs.

20. Evaluate the effectiveness of "short" loading vessels. Include the following in that evaluation:

    - System flow rate and residence time.
    - Channeling potential.

- Regulatory and design requirements.

6.8.2.2 Operation

1. Routine analysis of demineralizer influent and effluent for:

   - PH – organic media.
   - Conductivity – organic media.
   - TOC.
   - Activity.

   The sample analysis types may vary dependent on recycle or release process operations. The analyses results should be reviewed as soon as possible to evaluate processing performance.

2. The suggested sample frequency is outlined as follows:

   - **System influent** - prior to process system startup, facilitating appropriate configuration changes based on identified impurities.
   - **System effluent** - as soon as possible following at least one system volume turnover. Maximum within one hour of process startup to verify satisfactory performance.
   - **Individual component or vessel performance** - weekly or as appropriate based on overall system performance and influent quality.
   - **Following any known system or influent transients** - influent and effluent samples - immediately.

3. Train operators to ensure they have an adequate understanding of the process to effectively monitor system performance.

4. In addition to sampling, routine Chemistry support should be established to evaluate system performance, media usage, system configuration and waste minimization.

5. Consider the use of 0.22μ laboratory filter paper versus standard 0.45μ filter paper for determining soluble effluent from LRW treatment units.

6. Establish media configuration and changeout criteria based on known inputs and historical data. Develop demineralizer dose rate based activity limitations to ensure waste disposal remains cost effective.

7. When processing for recycle, perform a pre-service rinse to minimize the transport of manufacture and handling contaminants to system effluent.

8. Use bed dP data obtained during operations to evaluate particulate loading and the efficiency of deep bed prefiltration.

9. Develop outage plans to effectively process waste streams with varying chemistry and activity characteristics.

> **EXAMPLE:** One station has successfully addressed outage wastes by developing specific outage guidance in their "Liquid Radwaste Processing and Water Management Guidelines" procedure. The guidance includes borated water segregation for recycle without processing and the interface between the Radwaste Control Room Operator and the Water Management Coordinator to ensure that the impact on, and impact resulting from, LRW processing is minimized.

10. ***Resins should not be backwashed/fluffed after they have been in service.*** The solids and ionic loading that were retained will be redistributed, potentially to the bottom of the vessel, and impurities may leak to the system effluent. The chromatographic ion gradient in the vessel will be disturbed and increased ionic leakage will be evident.

6.8.2.3 Changeout

1. Prior to changeout, perform an evaluation of demineralizer liquid effluent to verify results are due to decreased demineralizer capacity and not caused by influent perturbations (i.e., particulate activity versus soluble activity leakage).

2. Consider holding a bed for decay of short lived isotopes prior to replacement. Multiple vessels must be available in the LRW system (e.g., three or more) to implement this practice.

3. Following bed transfer, perform an aggressive backwash or vessel rinse to ensure residual fines and other solids (the bathtub ring) have been effectively removed prior to recharging the vessel with new media.

4. Route decant waste liquid to a liner or storage tank containing waste resin. The resin can act as a particulate filter and any residual ion exchange capacity can be effective at reducing effluent activity prior to routing to the waste collection tanks.

5. Stop HIC fill prior to being full and flush with demineralized water to preclude resin line "clogging".

6. Use installed and portable shielding and low traffic routing for lines/hoses when practical to minimize personnel exposure during spent resin sluice operations.

7. Perform an inspection of vessel internals on a routine basis to determine condition of internal components.

8. Establish slurry water input flow rates to maintain the spent resin in a desirable, transferable consistency (e.g., 7 ft/second at a consistent flow rate).

6.8.2.4 Waste Packaging & Disposal

1. Analyze the site structural layout to ensure resin packaging and transport preparation evolutions are optimized. As part of that evaluation consider alternate use of existing facilities, addition of simple, cost effective alterations, and removal of equipment "retired in place" for optimizing the use of alternate space.

> **CAUTION:** Ensure changes to packaging strategies remain in compliance with the PCP, and container C of C and procedures.

2. Analyze the disposal fee structure to define the most cost effective packaging density and activity. As part of that analysis include density and activity changes on transportation fees and packaging and disposal options.

   When evaluating packaging requirements, include the following:

   - Container material, size, cost.
   - Density impact.
   - Dose rate.
   - Curie content.
   - VR and packaging efficiency.
   - Packaging equipment requirements.

3. Review activity limits developed above relative to resin dose rate, packaging, VR and disposal. Where applicable, adjust limitations to maximize the use of VR techniques and minimize disposal costs.

CAUTION:	The bottom dewatering laterals on powdered resin liners can be dependent on capillary action. To ensure compliance with disposal site residual liquid criteria, it may be prudent to load a bead resin bottom layer first, acting as a buffer to preclude clogging the dewatering laterals.

4. Evaluate activity based, direct on-land disposal off-site for low activity resins.

5. Evaluate increases in waste classification due to VR AND/OR increased packaging efficiencies. Ensure the parallel increase in packaging and disposal costs is less than the cost associated with the originally higher volumes at a lower specific activity and waste classification.

6. Analyze spent resin packaging and VR practices to ensure that the increased packaging efficiency does not increase the specific activity of nuclides such as carbon-14, nickel-63, and TRU to levels that result in > Class C waste.

6.8.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI product "waste*WORKS:*Wet Computer Code".
4. The EPRI document titled "Cost-Effective Liquid Processing Programs".
5. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".
6. A BWR Owners Group document on Condensate Polishing - Deep Bed and Filter Demineralizers.
7. A U.S. Nuclear Regulatory Commission Regulatory Guide titled "Maintenance of Water Quality in Boiling Water Reactors".
8. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".
9. An industry paper titled "An Overall Crud Reduction Program for Deep Bed Polishers in BWR Nuclear Plants".
10. An industry paper titled "Dowex Resins - BWR Condensate Polishing".
11. An industry paper titled "Relevance of Silica in Fuel Pool Purification".
12. The EPRI document titled "Spent Resin Disposition-Available Alternatives and Selection Analysis".
13. The EPRI document titled "In-plant Testing of Radwaste Ion Exchange Materials".

6.9 Program Element: Evaporators

6.9.1 Program Impact

The use of evaporators for processing LRW typically results in a high quality, low activity effluent suitable for recycle to reactor or condensate systems. In a few PWRs, evaporators are used for recovering boron from reactor letdown and draindown for recycle.

This section deals primarily with LRW processing, however much of the information can be used for boron recycle evaporation processes. Evaporator has been replaced by alternate technologies at the majority of stations. Industry experience has shown that this process frequently results in program attributes which include:

- High quality, low activity effluent.
- Relatively high maintenance costs

> **EXAMPLE:** In an effort to maintain evaporators in an operable condition, one station performed a major overhaul on one of three evaporators each fuel cycle. The estimated costs per overhaul including parts, labor, personnel exposure and waste disposition exceeded $500,000.

- Relatively high personnel exposure during maintenance and operation.
- Concentrates waste requiring final processing prior to disposal.

6.9.1.1 Use Issues

Evaporators can produce a high quality product, however they typically require a significant amount of operator attention during operation. In process and recycle applications, there is a significant benefit to achieving this quality relative to reactor water chemistry and its consequences. At several stations, antimony is a major component of the total effluent activity. The use of evaporators is an effective method for antimony removal. For process and release applications, the benefit of efficient processing is often overshadowed by operating and maintenance considerations.

The need for prefiltration and pre-demineralization is dependent on the influent quality. An evaporators function is to effectively concentrate impurities including solids, however, excessive impurity loading can foul heat transfer surfaces or result in carryover to the effluent stream. This issue becomes more critical with system influent fluctuations related to system maintenance, refueling (cavity draindown), and other outage evolutions.

Frequently, the performance of LRW evaporators is affected by surfactants and organics generated during routine and outage housekeeping and decon campaigns. These inputs can cause foaming and/or heat transfer loss resulting in decreased effluent quality. The energy required to operate an evaporator is also significant and those requirements are also negatively impacted by evaporator influent quality perturbations.

Many stations have also determined that operating boron recovery evaporators is not cost effective when compared to demineralization and release, procuring replacement boron and makeup water. Additionally, boron has a "useful" life and is depleted over time, requiring replacement. Boron recycle also has the potential to concentrate undesirable impurities such as silica, requiring periodic process and release or alternate processes to reduce the concentrations to an acceptable level. However, the potential for increased boron costs associated with the use of enriched boron as a reactivity control agent, may make evaporation for recycle a cost effective operation.

6.9.1.2 Operation

As discussed previously, evaporation requires a significant amount of Operator attention to maintain high quality effluent. The temperature and pressure, critical to the operation must be closely monitored and regulated to:

- Maximize boiling.
- Minimize carryover.
- Maintain concentrates density (weight percent-wt. %) within the desirable control band.
- Minimize energy demands.

The goal is to maximize heat transfer at the lowest temperature and highest process rate. In a properly operated evaporator, pressure can be effectively used to optimize these parameters.

During outages, the demands on operators rise with increased influent volume and the increased potential for lower quality influent following crudburst and cavity cleanup. The quality is also adversely affected by an increased input of surfactants and organic cleaners related to outage cleanup evolutions. Furthermore, steam and cooling water maintenance during refueling outages can result in evaporator down time during periods when influent volumes are often at peak capacity.

6.9.1.3 Maintenance

Evaporator maintenance is typically a costly process. There are costs associated with labor, parts, warehousing fees, personnel exposure and waste disposal. The use of routine PM and major overhauls, has proven to be effective at maintaining some evaporators in there optimum condition. However, as evaporators age and manufacturers focus on alternate technologies, parts become less available or require costly custom manufacture.

Some stations routinely clean evaporators using a chemical process. The goal is to improve heat transfer by removing impurities "cooked" on heat transfer surfaces. However, this process results in a chemical waste that requires treatment and disposal.

During operation, LRW and boron recycle evaporators tend to create an acidic environment inside the evaporator's components. pH monitoring and control capabilities are critical to ensure optimal evaporator performance and to minimize damage to internal components. When replacing components on any evaporator, an analysis of materials of construction can result in improved specifications and enhanced performance related to heat transfer and corrosion.

6.9.1.4 Waste Packaging & Disposal

Evaporator concentrates are typically dewatered and dried using thermal processes or solidified for disposal. While solidification is adequate for stabilization and methane gas minimization, it significantly increases the volume of waste requiring disposal. Thermal VR and packaging processes require additional on-site equipment and processes, or shipment of the slurry to off-site vendors for processing. LRW evaporator concentrates packaging and disposal options are primarily controlled by the activity and drying/VR processes. The following also impact process use and cost:

- Evaporator performance - wt. %.
- Plant structural and space constraints.
- Available plant drying/VR equipment.
- Available vendor services for on and off-site drying/VR.
- Liquid concentrates packaging and transport.
- Disposal pricing structure.
- Disposal availability (long and short term).

6.9.1.5 Exposure

As discussed previously, evaporator operation requires fairly close oversight and routine maintenance/overhauls. Evaporators also are not "rinsed" following use and activity buildup in components over time is typical. Concentrates handling operations related to transfer, drying/VR and packaging result in additional exposure. Evaporator chemical cleaning, while primarily intended to improve heat transfer coefficients can result in reduced dose rates for a period of time.

6.9.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

6.9.2.1 Use Issues

1. Calculate a cost for evaporator operations. This cost analysis should, at a minimum, include the following components:

    - Electricity costs for operation of pumps, etc.
    - Steam consumption for evaporator operation.
    - Cooling water demands.
    - Required spare parts inventory, warehousing and inventory taxes.
    - Feed and polishing demineralizer's media procurement and depleted media disposal costs.
    - Concentrates handling, drying/VR and disposal costs.
    - Operations costs (use loaded labor rates that include benefits).
    - Maintenance costs (include planning, labor and parts, annualize modification costs).
    - Exposure related costs ($/person-Rem).
    - Process rate in gpm.
    - Boron recycle - boron and makeup water replacement costs.

2. Evaluate and if possible, eliminate or minimize the use of evaporator feed filtration and demineralization. Consider the use of larger micron ratings on feed filters, minimizing waste generation, if filtration is retained.

3. Similar to feed demineralization, evaluate the need versus benefit for polishing ion exchangers. Frequently the cost associated with media procurement and disposal off-set the benefit derived from improved effluent quality.

4. Use the cost analysis above, evaluate the use of alternate processes for primary system waste. Filter and demineralization and membrane processing can frequently be more cost effective, meeting recycle or release requirements.

EXAMPLE: At least one station has reconfigured system line-ups to use installed evaporator demineralizers for routine processing without evaporation.

6.9.2.2 Operation

1. Provide operators with comprehensive training related to evaporator operation. As part of that training, include information related to concentrates disposal costs and evaporator effluent impact on reactor/condensate chemistry or plant liquid effluent activity.

2. Consider maintaining a dedicated crew of evaporator operators to maintain a high level of proficiency and to consistently achieve high quality performance results.

3. Develop plans for influent deviations. Evaporator operators can frequently provide valuable historical experience related to input's impact on performance - their input should be solicited to enhance the plan's success.

6.9.2.3 Maintenance

1. Perform PMs on a routine basis. Evaluate the use of major overhauls, alternating fuel cycles, to identify and replace worn components, overhaul instrumentation, and to improve heat transfer.

CAUTION: Carefully evaluate chemicals to be used to ensure cost effective treatment and/or disposal options are available. Additionally, ensure a mixed waste product will not be generated during this process.

2. Monitor heat transfer efficiencies and perform chemical cleanings on an as needed basis to improve heat transfer coefficient and reduce component activity buildup.

3. Evaluate improved materials of construction for replacement components and advanced technologies when replacing instrumentation to optimize performance.

6.9.2.4 Waste Packaging & Disposal

1. Analyze the site structural layout to ensure concentrates packaging and transport preparation evolutions are optimized. As part of that evaluation consider alternate use of existing facilities, addition of simple, cost effective alterations, and removal of equipment "retired in place" for optimizing the use of alternate space.

CAUTION:	Ensure changes to packaging strategies remain in compliance with the PCP, and container C of C and procedures.

2. Analyze the disposal fee structure to define the most cost effective packaging density and activity. As part of that analysis include density and activity changes on transportation fees and packaging and disposal options.

3. When evaluating packaging requirements, include the following:

    - Container material, size, cost.
    - Density impact.
    - Dose rate.
    - Curie content.
    - VR and packaging efficiency.
    - Packaging equipment requirements.

4. Process evaporator concentrates using an advanced thermal drying process in lieu of solidification. This results in a decreased volume of solid waste and improved packaging efficiencies. Better segregation of sources would make this an even more effective treatment method. Also consider super-compacting the containers of dried bottoms to achieve additional volume reduction.

EXAMPLE:	Recent data from a thermal drying system in use at the one plant suggests that the station would generate approximately 726 cu. ft. of solid waste from floor drain waste processing by evaporation with subsequent thermal treatment. Use their existing solidification process, the projected waste volume is 2612 cu. ft.

6.9.2.5 Exposure

1. Video tape evaporator maintenance activities. From those files, develop and use lessons learned and enhanced work practices to minimize personnel exposure.

2. Similar to the maintenance guidance, consider chemical cleaning on a periodic basis to remove activity from the system.

3. Evaluate evaporator operations and waste handling evolutions to identify potential improvements for personnel exposure reduction. As part of that evaluation, consider:

   - Frequency of operator interface with high activity components versus actual need.
   - Alternate routes for obtaining operational data.
   - The use of installed convex mirrors or remote video technology to minimize personnel entries into radiation or high radiation areas.
   - Installation of remote readouts.
   - The use of permanent or temporary shielding.

6.9.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".

6.10 Program Element: Membrane

6.10.1 Program Impact

In LRW processing applications, membrane technology is typically used to separate impurities over three orders of magnitude. The filtration types, in descending order of particle size removal, are referred to as microfiltration (MF), ultrafiltration (UF) and reverse osmosis (RO). Though widely used throughout the world in varying applications for more than three decades, these emerging technologies used in nuclear applications and are still somewhat in the research and development stage.

6.10.1.1 Influent Characterization & Membrane Selection

Utility experience with membrane processing has been varied and manufacturers and suppliers, eager to garner a share of the potential market are actively developing and testing membrane materials and manufacturing configurations. These include an array of spiral wound, hollow fiber and tubular configurations. In-plant experience has consistently demonstrated that influent waste stream knowledge and pretreatment are ***critical*** elements of successfully implementing this technology. The type of processing (MF, UF or RO), micron porosity, and the membrane materials are all dependent on impurity type and concentration.

The effects of off-standard influent can be devastating, fouling, irreversibly fouling, or chemically deteriorating membrane materials, requiring chemical cleaning or replacement. Therefore, a careful and accurate influent waste stream characterization is necessary prior to membrane selection and system design. Typical inputs, off-standard inputs and surge volumes would need be identified and characterized. Based on that influent characterization, membrane influent pretreatments would need to be evaluated and selected.

The membrane material selected should be compatible with chemical cleaning processes (typically recommended by the manufacturer). However, in nuclear applications, the potential for creating a mixed waste during chemical cleaning exists and may require selection of alternate membranes or chemical cleaning agents.

Desired system process rates also affect the selection and design process. Generally, membranes operate better at higher pressures to increase the membrane flux (gpm/ft^2), but the flow rate per square foot of membrane is lower than that of conventional media. Therefore, in an effort to increase the process rate, system designs typically incorporate several elements in series within a single pressure module, with several modules configured for parallel operation.

Lastly, membrane processing will require periodic membrane replacement. Waste handling and disposal options need to be considered to ensure the membrane type and configuration optimizes disposal options. An evaluation of system laydown plans should address the ability to effectively remove radioactive, contaminated membranes, and install replacements without incurring membrane damage.

6.10.1.2 Operation

Similar to evaporators, membrane system require careful operator oversight for successful operation particularly during initial startup and establishment of an operational experience data base. Support from the station chemistry organization is critical to effectively monitor influent waste stream characteristics and potential fluctuations.

Chemical cleaning will normally be required on a periodic basis - determined by influent quality, membrane design and operational experience. This cleaning will also help to minimize activity buildup. As discussed previously, pretreatment is a key element of successful processing using a membrane based system. The system operation should include careful oversight of that process, minimizing the potential for challenging membrane materials with undesirable inputs.

6.10.1.3 Membrane Changeout

When a membrane becomes irreversibly fouled, it will require replacement. Prior to removal, evaluate chemically cleaning the membrane to reduce activity levels to an acceptable level for handling, packaging and disposal. The costs associated with chemical cleaning and residual disposal should be less than the benefit derived by cleaning.

As discussed previously, the system configuration would need to facilitate changeout of radioactive, contaminated membranes and installation of replacements without damage.

6.10.1.4 Waste Packaging & Disposal

Properly sized membranes can be disposed in currently available waste packages for further off-site VR and/or disposal. Low dose membranes may be eligible for incineration processing resulting in a significant VR.

Membrane concentrates are typically dried using thermal processes prior to disposal. Thermal VR and packaging processes require additional on-site equipment and processes, or shipment of the slurry to off-site vendors for processing.

Membrane concentrates packaging and disposal options are primarily controlled by the activity and drying/VR processes. The following also impact process use and cost:

- Concentration density - wt. %.
- Plant structural and space constraints.
- Available plant drying/VR equipment.
- Available vendor services for on and off-site drying/VR.
- Liquid concentrates packaging and transport.
- Disposal pricing structure.
- Disposal availability (long and short term).

6.10.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

6.10.2.1 Influent Characterization & Membrane Selection

1. The general waste stream characteristics that should be evaluated prior to membrane selection include:

    - Influent pH.
    - Conductivity.
    - Particle size and abundance using various techniques.
    - Activity.
    - Organic concentration.
    - Chemical presence and concentration (i.e., boron, closed cooling water treatment chemicals).
    - Microorganism abundance.
    - Anticipated variations in influent quality.
    - Process volume.

    Prior to membrane selection, the waste stream should be further characterized to identify inputs from external sources that impact process efficiency or challenge membrane materials.

2. Working with the supplier, determine the desired system performance parameters. As part of that assessment include the following:

    - Use of hard piping to preclude hose failures associated with system high pressures.
    - Compatibility with existing feed tanks, pumps and system piping.
    - Required process flow rate to meet plant needs - normal and surge volumes.
    - Membrane flux and desired impurity rejection rate.
    - Minimum flow rate to preclude membrane fouling.
    - Design pressure required to achieve the desired process rate.

3. Evaluate membrane VR and disposal options, minimizing disposal costs to the extent practical without compromising membrane performance.

4. Verify that recommended chemical cleaning's waste treatment and/or disposition is compatible with federal, state and local regulations and is cost effective.

5. Consider changeout space requirements when specifying membrane configuration and system layout.

6.10.2.2 Operation

1. Initially dedicating a select crew to train and operate the system. The team should include a chemistry process expert.

2. Carefully monitor plant evolutions and waste inputs to minimize challenges to the system. Influent waste chemistry parameters should be analyzed on a routine basis.

3. Contact other stations using membrane processing to capture current lessons learned.

4. Perform chemical cleanings based on manufacturer's recommendations, system performance and the plant specific experience base once established.

6.10.2.3 Membrane Changeout

1. Verify that membrane changeout considerations are addressed when designing the system configuration and laydown footprint. As part of that assessment consider:

    - Physical access and maneuverability.
    - Personnel exposure controls.
    - Contamination controls.
    - Membrane transport to shipping packages.
    - Successful replacement membrane installation.

2. Perform membrane changeouts based on manufacturer's recommendations, system performance, activity and the plant specific experience base once established.

3. Evaluate chemical cleaning benefit prior to changeout. As part of that analysis, consider the following:

    - Chemical procurement costs.
    - Chemical waste treatment and/or disposition.
    - Membrane packaging, VR and disposition options at pre and post cleaning activity levels.
    - Labor support costs.
    - Expected exposure reduction.
    - Station cost per person-Rem.

6.10.2.4 Waste Packaging & Disposal

1. Review station activity limits relative to membrane dose rate, VR and disposal. Where applicable, adjust limitations to maximize the use of VR techniques and minimize disposal costs.

> **CAUTION:** Ensure changes to packaging strategies remain in compliance with the PCP, and container C of C and procedures.

2. Analyze the disposal fee structure to define the most cost effective membrane and concentrates packaging density and activity. Include as part of that analysis items such as density and activity changes on transportation fees and packaging and disposal options.

   When evaluating waste packaging requirements, include the following:

   - Container material, size, weight and cost.
   - Stabilization requirements.
   - Density impact.
   - Concentrates transport and shipping container disposition.
   - VR and packaging efficiency.
   - Curie content.
   - Dose rate.
   - Packaging equipment requirements.

3. Evaluating increases in waste classification due to VR and/or increased packaging efficiencies to ensure the parallel increase in packaging and disposal costs is less than the cost associated with the originally higher volumes at a lower specific activity and waste classification.

4. Analyze spent membrane VR practices to ensure that the increased packaging efficiency does not increase the specific activity of nuclides such as carbon-14 nickel-63 and TRU, to levels that result in > Class C waste.

5. Analyze the site structural layout to ensure membrane VR, packaging and transport preparation evolutions are optimized. As part of that evaluation consider alternate use of existing facilities, addition of simple, cost effective alterations, and removal of equipment "retired in place" for optimizing the use of alternate space.

6.10.3 Cross Reference(s):

None

6.11 Program Element: Separation – Centrifuge/Cyclone

6.11.1 Program Impact

This technology has proven to be effective for processing some waste streams at commercial reactor sites and for government related projects. However, the current industry experience was insufficient to provide accurate, useful guidance on this process technology.

Section 7 Balance of Plant Process Systems

7.1 Program Element: Cartridge Filters

7.1.1 Spent Fuel Pool Skimmer

7.1.1.1 Program Impact

SFP skimmer filter's primary function is to remove surface particulate such as pollen and dust to maintain pool surface clarity. Removal of solids by the skimmer filter may also prolong the life of SFP demineralizers and filters depending on the system configuration. A second objective is to remove particulate activity. These cartridge filters are typically expensive, difficult to handle and result in an extremely poor disposal packaging efficiency.

7.1.1.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

The station should review and evaluate the objective for use of the skimmer filter. If clarity is the only concern, go to 1 below. If solids removal is required to extend the life of other media, go to number 2.

1. Pool Clarity

- Secure the installed SFP skimmer system when not needed for refueling operations to maintain clarity so as to reduce spent filter generation.
- Increase the particle rating for the installed filters to the largest micron size with out compromising the maintenance of surface clarity. In many cases the rating can be increased to at least 20 micron.
- Since installed skimmers often cause ripples which hamper pool clarity, consideration should be given to the use of a floating skimmer saucer attachment to an underwater vacuum system and abandoning the installed system.

2. Solids Removal

- The input of solids into the open SFP system can result in the fouling of SFP demineralizers prior to chemical depletion. If this is experienced, the use of fine pore skimmer filters at all times may be warranted to reduce overall radwaste generation. High dirt capacity filter media will be required to increase the life of such cartridges. In general, polymer media will have a higher dirt capacity than cellulose and glass a higher dirt capacity than polymer. The micron size needed to remove dust will be 1 micron or less.

7.1.1.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
3. An industry paper titled "Relevance of Silica in Fuel Pool Purification".

7.1.2 Spent Fuel Pool Deep Bed Prefiltration

7.1.2.1 Program Impact

This filter's function is primarily for the prefiltration of influent to the demineralizer to preclude solids fouling of the resin. A second objective is to remove particulate activity from the SFP. These cartridge filters are typically expensive, difficult to handle and result in personnel exposure as well as an extremely poor disposal packaging efficiency. General area exposure rates from the SFP are usually due to soluble activity versus particulate activity. It is important to insure that demineralizer treatment of SFP liquid is not reduced excessively by down time required to replace this prefilter.

7.1.2.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Determine the micron rating required to insure the demineralizer depletes chemically prior to solids fouling. This may enable the micron size of the filter to be increased which will reduce spent filter generation and system down time. For highly selective organic resin, which tend to adsorb dust, this may require a filter size reduction to 1 micron or less. Reducing the filter size must be balanced with the resultant system down time to insure general area exposure rates do not increase to an unacceptable level.

2. The use of sub-micron coolant filters can greatly reduce hot particles and thus reduce waste generation from contamination control programs. Sub-micron filters also reduce the source term from the primary system lowering exposure some what in containment and from the cavity. Sub-micron filters can also reduce the wear on pump seals and protect other coolant pump components.

3. Track data from routine SFP activity samples to insure pool particulate activity does not increase to an unacceptable level or adversely impact the contamination control program.

7.1.2.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
2. An industry paper titled "Relevance of Silica in Fuel Pool Purification".

7.1.3 Reactor Coolant

7.1.3.1 Program Impact

Reactor coolant cartridge filters are typically expensive, difficult to handle and result in personnel exposure as well as extremely poor disposal packaging efficiency. Plant evolutions, operating conditions and reactor coolant chemistry parameters can dramatically affect the size and abundance of particles in the system. The selection of and performance criteria for reactor coolant cartridges are affected by conflicting goals relative to source term control, exposure control, water chemistry quality improvements, hot particle contamination control and waste reduction.

Many PWRs have altered their reactor coolant filter pore size from 5micron nominal in the 1970's or 2 micron absolute in the 1980's down to sub-micron filters in the 1990's.

The use of sub-micron coolant filters can greatly reduce hot particles and thus reduce waste generation from contamination control programs. Sub-micron filters also reduce the source term from the primary system lowering exposure some what in containment and from the cavity. Sub-micron filters can also reduce the wear on pump seals and protect other coolant pump components.

Planned shut down crud bursts and by pass of the letdown demineralizer for hydrazine add during startup result in rapidly loading these filters. Letdown cleanup system down time due to filter cartridge replacement can adversely affect exposure and source term reduction. Similarly, coolant pump cycling during fill and vent evolutions at startup, can create mini crudbursts that adversely affect filter throughput and solid waste generation. The use of primary coolant vacuum fill techniques has proven to be an effective alternative for minimizing the concentration of crud released and hence the number of waste filters generated.

Sub-micron filters, however, concentrate carbon-14 which could result in increased waste generation and complicated controls in order to avoid producing greater than Class C waste. Additional coolant filters also increase the effort that must be expended to safely handle and package this high activity waste stream. Coolant cleanup system down time required to replace plugged filters can adversely affect exposure control.

7.1.3.2 Guidance

The station should evaluate and implement as appropriate the following program guidance:

1. Characterize, select and install absolute rated filters for optimal particle removal.

2. Use a stepped approach to reducing letdown filter micron size. The costs associated with cartridge procurement, system down time, spent filter handling equipment, storage and disposal can be analyzed relative to the filter pore size.

3. Use vacuum fill methods to the extent possible to minimize the volume of crud generated during primary coolant fill and vent evolutions.

4. Consider increasing the micron rating of the RCS letdown filter prior to unit shut down and start up.

5. Increasing cartridge size to a 1 or 2 micron prior to crud bursts and returning to a sub-micron cartridge when the unit is at full power is one technique to balance conflicting goals.

7.1.3.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3 Part 1: Processing Liquid Waste".
2. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
3. An industry paper titled "Reduced Particulate and Colloidal Cobalt Activity in Liquid Radwaste".

7.2 Program Element: Precoat Filters

7.2.1 Condensate

7.2.1.1 Overview

Typically, the performance of condensate filter demineralizers (CFD) at U.S. nuclear power plants falls considerably below the intended performance objectives for these systems. The original design is based on the following:

average service runs .... 28 days

filter capacity .... 0.1 lb. of crud per 1.0 lb. of resin (10% wt.)

filter efficiency .... iron removal of >90%

A few of the U.S. plants equipped with CFD's have achieved a satisfactory performance level with respect to one or all of the design objectives, i.e., length of service runs, filter capacity, or filter efficiency. However, the majority of plants are considerably below the intended performance indices. Equally important is the range of experience seen in the operation of these systems.

Compounding the significance of this deviation in performance is the fact that the cost associated with the disposal of radioactive wastes from CFD has increased significantly when compared to existing costs at the time of design. The disposal cost for an average BWR is projected to be approximately 50 to 75% of the plant's total wet waste disposal budget. Furthermore, when cellulose fiber is used in the CFD, biogassing can result in solid wet waste containers.

Over the last several years, many stations implemented hardware changes in an attempt to improve the overall performance of condensate polishers resulting in varying degrees of success. One of the most significant changes was the installation of advanced design septa requiring either minimal or no precoat media.

In some instances this technology resulted in significantly longer run lengths - processing more than six times the volume of condensate per volume of precoat. Additionally, as a result of this enhancement, many utilities experienced an improvement in the quality of feedwater chemistry.

7.2.1.2 Guidance

Guidance is contained in the cross reference(s) identified below.

7.2.1.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
4. The EPRI document titled "Proceedings; Second Workshop on Condensate Polishing with Powdered Resin".
5. An industry document titled "Reactor Water Cleanup Systems, a Comprehensive Summary of Design, Corrective Actions and Improvements".
6. The EPRI document titled "BWR Normal Water Chemistry Guidelines".
7. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
8. A U.S. Nuclear Regulatory Commission Regulatory Guide titled "Maintenance of Water Quality in Boiling Water Reactors".
9. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".
10. The EPRI document titled "Condensate Polishing Guidelines for PWR and BWR Plants".
11. The EPRI document titled "New Technology in Condensate Polishing".
12. A BWR Owners Group document on Condensate Polishing - Deep Bed and Filter Demineralizers.

7.2.2 Reactor Water Cleanup

7.2.2.1 Program Impact

A full dose precoat is utilized for reactor water cleanup (RWCU) filter/demineralizers to maximize impurity cleanup. The RWCU system has a major impact on the overall reactor coolant chemistry and therefore, the use of minimum or non precoat septa (i.e., no-to-minimal ion exchange) is currently not practiced. The precoat is typically backwashed based on activity levels frequently with remaining ion exchange capacity. This is a good practice as it minimizes the development of radioactive "hot spots" during backwash evolutions, reducing personnel exposure. Maintaining the spent media activity at lower levels can reduce waste packaging, transport and disposal costs.

Additionally, the amount of RWCU flow dictates the chemical concentration factor for the reactor vessel. Many plants have considered increasing the flowrate, but have not been able to due to regenerative/nonregenerative heat exchanger limitations and the effect on thermal performance.

The system operates at high pressure (~1,000 psi) and therefore isolation valves often leak-by creating problems during precoating.

7.2.2.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Evaluating all goals that impact media selection and backwash criteria. Include the following in the analysis:

    - Costs associated with personnel exposure, media procurement, backwash, precoat and disposal.
    - Exposure associated with reduced source term, media backwash, packaging, and disposal.
    - Impact of backwash frequency on reactor chemistry.

2. Maintain block valves in a fully operational condition, repairing, upgrading valve components, or replacing the valves as necessary.

3. **Additional guidance is contained in the cross references identified below.**

7.2.2.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
4. The EPRI document titled "Proceedings; Second Workshop on Condensate Polishing with Powdered Resin".
5. An industry document titled "Reactor Water Cleanup Systems, a Comprehensive Summary of Design, Corrective Actions and Improvements".
6. The EPRI document titled "BWR Normal Water Chemistry Guidelines".
7. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
8. A U.S. Nuclear Regulatory Commission Regulatory Guide titled "Maintenance of Water Quality in Boiling Water Reactors".
9. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".
10. The EPRI document titled "Preventing Biogassing in Low Level Waste, an Interim Report".

7.2.3 Spent Fuel Pool

7.2.3.1 Program Impact

The principal function of SFP purification systems is to maintain *water clarity* for underwater operations. In addition, these systems control fuel pool water *purity* and *radioactivity* associated with the storage of nuclear fuel.

This is accomplished using either precoated filter/demineralizers or a prefilter followed by deep bed demineralizer. The preference for precoated filters is consistent with the view that the *principal function* is the removal of particulate material.

The need for providing a high capacity water purification, i.e., deep bed demineralizers is viewed as unwarranted. This is based on the pools being essentially closed system where the impurities of concern originate from fuel releases and makeup water. To a great extent ionic impurities originate from the makeup water used to replace evaporation losses.

As straight forward as the purification of fuel pool water would appear, it is apparent that the industry would benefit from a reexamination of such operations. Considerable variation exist between plants in the water purification strategy being used in the operation of their fuel pools. Most precoat filters are backwashed based on dP, or less often, chemical breakthrough, precoat activity level or a combination of these factors.

In an open fuel pool the major ion exchange load is associated with carbon dioxide dissolved at the pool's surface. This innocuous dissolved gas depletes the precoat anion exchange component. However, ion exchange resin selectivity shows a decided preference for the other ionic species. Anion resin selectivity in decreasing order is as follows:

Sulfate > Nitrate > Chloride > **Bicarbonate** > Silica
(From air)

The aggressive anion species of concern to the nuclear industry (sulfate, chloride) are preferred over the air inducted bicarbonate. This means, that resin depleted by bicarbonate still retains ion exchange capacity for such ions as sulfate, nitrate and chloride. Silica on the other hand is significantly affected by the introduction of carbon dioxide (bicarbonate) to the water.

The role of silica in industry water quality standards is often misunderstood. Under the EPRI present BWR water chemistry guidelines, silica is identified as a *"diagnostic parameter."* Monitoring this impurity is viewed as "a valuable indication of the effectiveness of the RWCU system." No chemistry "Action Level" has been established for silica, since it is seen only as a diagnostic impurity. It should be noted, that EPRI is presently investigating the effect of silica on fuel cladding corrosion.

The application of silica as a diagnostic indicator in fuel pool purification is viewed as inappropriate. The fuel pool is an aerated system and the RWCU is high temperature deaerated system. This difference can significantly alter the behavior of silica in ion exchange material. There are two principal reasons for eliminating the use of silica as a diagnostic tool for assessing fuel pool processing media depletion.

1. Silica is normally present in water in only minor concentrations. Since it is only weakly held on the ion exchange media, it becomes the first leak from the bed upon media depletion. Once silica is seen in the discharge stream, other more important ions are soon to follow. In the fuel pool case, the lag time between silica breakthrough and that of aggressive impurities (chloride, sulfate) can be significantly longer than in standard F/D operations.

2. The second reason is tied to the use of a silica containing material in new high density fuel racks. A majority of plants have expanded fuel storage capacity by replacing the original storage racks with new racks with higher fuel packing density. Many of these rack designs incorporate sheets of a silica based neutron absorber material for fuel reactivity control.

   The material is a dimethyl polysiloxane polymer (silicone rubber) with boron carbide incorporated as the neutron absorber. Recent utility coupon test programs indicate unexpected gamma radiation induced changes in the material. Physical changes have been seen in the material with respect to dimensions, color, weight and elasticity.

   Significant increases of silica levels in the pool water has been noted with racks using this material. For plants controlling F/Ds based on effluent silica, the impact can be significant in terms of waste generation. Where the pool purification focuses on particulate removal, silica is allowed to reach several *parts per million* and waste generation is relatively insignificant.

7.2.3.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

> **NOTE:** Segregate SFP and cavity liquids to the extent possible (e.g., don't line up SFP demineralizer effluent to the cavity)

1. Establish water clarity as the primary purification objective. This is consistent with the industry's accepted operating guidelines and accepted water quality standards. Water purification would be used <u>as needed</u> to maintain the water to an acceptable level for contamination and exposure control in the refueling area. In only the most unusual circumstances, would continuous filter/demineralization be required to control soluble ion species to acceptable limits.

2. Segregation of SFP, cavity and other liquid streams should be maintained to the maximum extent practical. Silica and other chemical species can adversely affect reactor water quality, and/or fuel integrity.

7.2.3.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
4. The EPRI document titled "Proceedings; Second Workshop on Condensate Polishing with Powdered Resin".
5. An industry paper titled "Relevance of Silica in Fuel Pool Purification".

7.3 Program Element: Non and Minimum Precoat Filters

7.3.1 Condensate

7.3.1.1 Program Impact

The use of non or minimum precoat filtration for condensate filtration has been implemented at several stations. The primary objective for converting to non or minimum precoat technology is to improve iron removal efficiency.

A second objective is to reduce solid radwaste volume. Elimination of precoat resin in the CFD system while maintaining or increasing filter performance is possible with non-precoat filtration. A third objective is to reduce operation and maintenance expenditures. CDD life expectancy is increased with a lower fouling potential with non-precoat filters. The final objective is exposure reduction, both on-line and during element change-out. Industry experience indicates that iron transport reduction leads to tangible exposure reduction benefits. EPRI work on non-precoat filters has shown an unexpected benefit of low activity build-up on non-precoat surface filters.

The CFD system is typically one of the largest solid radwaste producers in BWR stations. The elimination or minimization of precoat media can significantly reduce the volume of solid radwaste requiring disposal, while also reducing biogas potential. However, these process changes can also negatively impact LRW processing operations by challenging the system with high concentrations of iron in the backwash stream that is typically routed to LRW.

7.3.1.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Implement the use of a pleated filter technology to dramatically increase the effective filter surface area. This will reduce the operating flux rate of CFD vessels. A lower flux rate typically provides more throughput to a dP endpoint.

2. Selecting a filter element pore size to optimize particulate removal efficiency, desired throughput, and backwash efficiency.

EXAMPLE: In order to minimize personnel exposure during element removal, one station devised an innovative condensate filter element transfer device. The device was constructed of schedule 40 PVC pipe and vacuum lines. Each filter was placed into the tube and the spring assembly cut off with a portable band saw. The tube was under a vacuum and the element was "shot" into the burial liner, which was staged in a horizontal position. This allowed the filters to be stacked lengthwise in a horizontal position. This design allowed all 420 elements to be packaged in 1 liner instead of the typical 2 resulting in $75,000 savings per burial liner. In addition, the filter transfer device prevented contaminated water and debris from spreading out in the work area. Total exposure for the job was approximately one-half of previous changeouts in spite of higher filter dose rates.

3. **Additional guidance is contained in the cross references identified below.**

7.3.1.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Filter Demineralizer Performance Improvement Program".
2. An industry paper titled "A Case Study of the use of Non-Precoat Filters in BWR Condensate Polishing: Full Unit Results".

7.4 Program Element: Condensate System Prefiltration

7.4.1 Program Impact

Several generating plants are considering or have retrofitted their condensate systems with prefilters to protect critical steam generating components, to meet long-term water quality and achieve long-term radiation exposure goals.

The use of non or minimum precoat filters as prefilters for the Condensate Deep Bed Demineralizers (CDD), provides enhanced resin iron fouling protection. Iron fouled deep bed resins lose kinetic efficiencies which are critical for a brackish water cooled plant in the event of a condenser tube leak. Such filters greatly reduce resin cleaning requirements that would disturb the chromatographic bands in the deep bed polishers, compromising water quality.

The use of prefiltration also results in less iron transport to the downstream deep bed condensate polishers preventing iron from fouling ion exchange sites. In PWRs, a more efficient resin regeneration can be performed since regenerant chemicals more easily reach ion exchange sites. Separation becomes easier since iron foulant does not impact specific gravities of anion and cation resins. With the use of alternate amine chemistries, separation efficiency becomes more critical.

The use of prefiltration also results in less iron transport to the downstream deep bed condensate polisher minimizing dP buildup. In BWR's this means minimization of URC's. A single URC typically generates between 15,000 and 30,000 gallons of waste liquid, with some stations generating > 45,000 gallons per URC. If the bed is not disturbed during operation, the best water quality can be maintained. All chromatographic bands remain intact until the resin is ultimately replaced. Low contaminant leakage becomes of vital importance during a condenser tube leak situation.

Less iron transport leads to lower in- and ex-core radiation dose rates. Iron has been demonstrated to be a carrier for feedwater borne corrosion product transport to in-core heat transfer surfaces. In PWR's, iron accumulates in steam generators leading to crevice corrosion-sites. Corrosion product transport control is a necessity to ensure the generators last for the life of the plant. In BWR's, iron migrates to the fuel surface, where corrosion products become activated. These activated corrosion products then are incorporated into piping corrosion films or settle out in low flow areas during crud bursts.

In BWRs that are using zinc injection, less iron transport leads to reduced zinc oxide additions to the feedwater. For plants using natural zinc oxide, less Zn-65 isotope is produced with lower feedwater iron concentrations. For plants using depleted zinc oxide, a significant cost savings in chemicals is achieved.

7.4.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Carefully evaluate the use of prefiltration in this application. As part of that evaluation consider:

    - Significant costs typically associated with hardware retrofits.
    - Alternative resin cleaning processes to improve resin efficiency and life, potentially reducing waste volumes.

7.4.3 Cross Reference(s):

Appendix A - Reference(s):

1. A BWR Owners Group document on Condensate Polishing - Deep Bed and Filter Demineralizers.
2. A U.S. Nuclear Regulatory Commission Regulatory Guide titled "Maintenance of Water Quality in Boiling Water Reactors".
3. An industry paper titled "An Overall Crud Reduction Program for Deep Bed Polishers in BWR Nuclear Plants".
4. An industry paper titled "Dowex Resins - BWR Condensate Polishing".

7.5 Program Element: Deep Bed Demineralizers

7.5.1 Condensate

7.5.1.1 Program Impact

The primary function of deep bed condensate polishers is to protect the steam generators (PWR) or the reactor (BWR) from major impurity ingress during condenser tube leaks. A secondary function is the removal of soluble and insoluble impurities forwarded to the feedwater system.

For BWRs, Regulatory Guide 1.56 mandates that ion exchange resin have 60% of original ion exchange capacity remaining to protect the reactor from a condenser tube leak situation. This requirement typically results in deep bed changeout prior to chemical depletion. Additionally, the exposure of the anion component to atmospheric conditions (no condenser vacuum) can also result in premature depletion of the media, again requiring early changeout.

Deep bed condensate polishers do not perform as well as filters. Typical insoluble corrosion product removal efficiency is in the 65-85% range. The removal efficiency is dependent upon factors that include, but are not limited to, hotwell insoluble corrosion product concentration, condensate flow rate, resin cleaning frequency, and resin age.

Deep bed ion exchange resins remove corrosion products both by mechanical filtration and electrostatically. Filtration is physically accomplished by the resin particle size and size distribution. Smaller resin particle sizes will increase filtration efficiency at a cost of dP, requiring more frequent cleaning or replacement, both of which negatively impact radwaste programs.

7.5.1.2 Guidance

Guidance is contained in the cross references identified below.

7.5.1.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. A BWR Owners Group document on Condensate Polishing - Deep Bed and Filter Demineralizers.
4. The EPRI document titled "BWR Normal Water Chemistry Guidelines".
5. A U.S. Nuclear Regulatory Commission Regulatory Guide titled "Maintenance of Water Quality in Boiling Water Reactors".
6. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".
7. An industry paper titled "An Overall Crud Reduction Program for Deep Bed Polishers in BWR Nuclear Plants".
8. An industry paper titled "Dowex Resins - BWR Condensate Polishing".

7.5.2 Reactor Letdown and Reactor Water Cleanup

7.5.2.1 Program Impact

Deep bed ion exchangers, used in all domestic PWR stations for reactor coolant letdown demineralization, are utilized in very few BWR plants. This is primarily due to the significant plant thermal loss associated with cooling the purification stream to obtain a desired BWR flow rate of 1,000 gpm. These beds are typically removed from service on conductivity, chlorides or nuclide break. The spent media is very high in activity making packaging, transportation and disposal costly.

The activity level of the spent media is typically too high for off site volume reduction and activity based disposal fees further increases the costs associated with spent media disposal for such beds. Storage of the spent media for radioactive decay is one method to reduce the cost of disposal. There is no additional curie charge for activity in excess of 400 Ci per container. Extending the life of these beds so as to remove in excess of 400 Ci of long lived nuclides is another method to counter the increased disposal cost.

The replacement of these beds immediately after depletion can adversely affect the exposure control program and input high activity and high particulate sluice water into the liquid radwaste system. Such liquids may be difficult to process and can adversely affect liquid effluents. Holding a depleted bed in it's vessel for radioactive decay prior to replacement can reduce the impact on the liquid radwaste system and the exposure control program. Such decay may also reduce disposal fees.

7.5.2.2 Guidance

The station should evaluate and implement as appropriate the following program guidance:

1. Determine the reason for bed replacement. Cation capacity depletion may be the cause for replacement or anion capacity. Evaluate whether the reason for replacement changes from one bed to the next.

2. Consider an alternate supplier of resin. Organic resin from one vendor may have a higher capacity for soluble species than what is currently in use.

> **CAUTION:** The station should carefully review FSAR, Licensing documents and safe shutdown requirements prior to altering resin ratios to ensure regulatory compliance. The use of a 10CFR50.59 evaluation may be required or prudent to document procedural and regulatory compliance.

3. If the cause for bed replacement is inconsistent, consider altering the ratio of cation to anion as appropriate. Any change in the resin ratio must be evaluated for impact on design basis documents and safe shutdown requirements.

4. If the expensive lithiated letdown bed is always replaced due to shutdown crud bursts, consider use of a separate bed to cleanup the crud burst. An inexpensive non lithiated mixed bed, possibly with a high cation load, can be used for shutdown service, preserving and extending the life of the lithiated mixed bed. Many plants have implemented this practice. This practice also enables decay of the shutdown bed for a full fuel cycle prior to replacement. However, multiple vessels must be available in the letdown system (e.g., three or more) to implement this practice.

5. If multiple vessels are available in the cleanup system, consider segregated loading of cation and anion resin. RCS cleanup would be provided by aligning the cation and anion vessels in series. Such a change must be evaluated for impact on design basis documents and safe shutdown requirements. Segregated loading enables low dose spent anion resin to be disposed of separately from high activity cation resin, greatly reducing cost. Off site volume reduction of anion resin is possible, further reducing the disposal cost.

6. When evaluating packaging requirements, include the following:

    - Container material, size, cost.
    - Density impact.

- Curie content.
- Dose rate.
- VR and packaging efficiency.
- Packaging equipment requirements.

7.5.2.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. An industry document titled "Reactor Water Cleanup Systems, a Comprehensive Summary of Design, Corrective Actions and Improvements".
4. The EPRI document titled "BWR Normal Water Chemistry Guidelines".
5. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
6. A U.S. Nuclear Regulatory Commission Regulatory Guide titled "Maintenance of Water Quality in Boiling Water Reactors".
7. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".
8. An industry paper titled "An Overall Crud Reduction Program for Deep Bed Polishers in BWR Nuclear Plants".
9. An industry paper titled "Dowex Resins - BWR Condensate Polishing".
10. "Full-Scale Performance of New Ion Exchange Materials for Processing Low Level Liquids at Diablo Canyon Power Plant," KL James, CC Miller, Waste Management '90, Tucson, AZ 1990.
11. The EPRI document titled "Analyzing Advanced Liquid Waste Minimization Techniques at a PWR: Advanced Media, Pleated Filters, and Economic Evaluation Tools".

7.5.3 Spent Fuel Pool

7.5.3.1 Program Impact

The function of this bed is to provide proper water chemistry and clarity for the safe storage of fuel for reuse and safe long term storage of spent fuel. A second objective is to insure general area exposure rates do not increase to an unacceptable level. The use of a deep bed supports the view that water purification, to limit corrosion of the fuel, and removal of nuclides from potentially failed fuel elements are the principal functions.

For deep beds the change out criteria varies through out the industry. The break through of chloride, fluoride or sulfate and nuclides are most often used. However, pH and silica break through are used at other plants.

If exposure control is a concern, the deep bed will need to be aligned for SFP cleanup more often. In such situations, the spent media may be high in activity making packaging, transportation and disposal costly. Since most pools are provided with only one vessel, the replacement of such beds must be performed immediately. This requirement eliminates any possibility of radioactive decay to reduce the impact of high activity sluice water on the liquid radwaste system. In such situations, removal of radioactive particles from the SFP via installed cartridge filters or under water vacuum filters may be preferable to collecting particulate on resin which will be liberated during the replacement of the bed.

If proper water chemistry for fuel storage is the major concern, the strategy for water purification should be carefully reviewed. In an open pool the major ion exchange load is associated with carbon dioxide dissolved at the pool's surface. This innocuous dissolved gas depletes the anion resin. However, ion exchange resin selectivity shows a decided preference for the other ionic species. Anion resin selectivity in decreasing order is as follows:

Sulfate > Nitrate > Chloride > **Bicarbonate** > Silica
(From air)

The aggressive anion species of concern to the nuclear industry (sulfate, chloride) are preferred over the air inducted bicarbonate. This means, that resin depleted by bicarbonate still retains ion exchange capacity for such ions as sulfate, nitrate and chloride. Silica on the other hand is significantly affected by the introduction of carbon dioxide (bicarbonate) to the water.

The role of silica in industry water quality standards is often misunderstood. Under the EPRI present BWR water chemistry guidelines, silica is identified as a *"diagnostic parameter."* Monitoring this impurity is viewed as "a valuable indication of the effectiveness of the RWCU system." No chemistry "Action Level" has been established for silica, since it is seen only as a diagnostic impurity. It should be noted, that EPRI is presently investigating the effect of silica on fuel cladding corrosion. The data gathered to date is inconclusive as to the role of silica in fuel cladding corrosion.

The application of silica as a diagnostic indicator in fuel pool purification is viewed as inappropriate. The fuel pool is an aerated system and the RWCU is high temperature deaerated system. This difference can significantly alter the behavior of silica in an ion exchange bed. There are two principal reasons for eliminating the use of silica as a diagnostic tool for assessing fuel pool resin depletion.

1. Silica is normally present in water in only minor concentrations. Since it is only weakly held on the ion exchange resin, it becomes the first leak from the bed upon resin depletion. Once silica is seen in the discharge stream, other more important ions are soon to follow. In the fuel pool case, the lag time

between silica breakthrough and that of aggressive impurities (chloride, sulfate) can be significantly longer than in standard demineralizer operations.

2. A majority of plants have expanded fuel storage capacity by replacing the original storage racks with new racks with higher fuel packing density. Many of these rack designs incorporate sheets of a silica based neutron absorber material for fuel reactivity control.

   The material is a dimethyl polysiloxane polymer (silicone rubber) with boron carbide incorporated as the neutron absorber. Recent utility coupon test programs indicate unexpected gamma radiation induced changes in the material. Physical changes have been seen in the material with respect to dimensions, color, weight and elasticity.

   Significant increases of silica levels in the pool water has been noted with racks using this material. For plants controlling demineralizers based on effluent silica, the impact can be significant in terms of waste generation. Where the pool purification focuses on particulate removal, silica is allowed to reach several *parts per million* and waste generation is relatively insignificant.

7.5.3.2 Guidance

The station should evaluate, and implement as appropriate the following program enhancement guidance:

1. Consider adopting water clarity as the primary purification objective. This is consistent with industry's accepted operating guidelines and accepted water quality standards. Such a change must be evaluated for impact of design basis documents and fuel vendor specifications.

2. Water purification should be used as needed to maintain an acceptable general area exposure rate near the pool or to maintain the contamination control program. Placing the system in service only as required will reduce radwaste generation.

3. Consider an alternate supplier of resin. Organic resin from one vendor may have a higher capacity for soluble species than what is currently in use.

4. If sulfates or anions are not an issue, consider increasing the ratio of cation to anion in the bed.

EXAMPLE:	A 3:1 cation to anion volumetric ratio has been used successfully to extend the life of SFP beds to two years in continuous service.

5. Eliminating silica as a demineralizer control limit. Water clarity and control of aggressive ions, e.g., sulfate, chloride and nitrate, are the principal changeout parameters. Silica would not be used to determine replacement of ion exchange resin. Resin change out would be based on chloride, nitrate or sulfate breakthrough.

EXAMPLE: One BWR modified their operating strategy for the fuel pool purification system. The system consisted of an etched disc filter followed by a deep bed demineralizer. The demineralizer contains 90 ft^3 of ion exchange resin with an anion to cation ratio of 2 to 1. Throughout the plant's operating life, the replacement of demineralizer ion exchange resin was based on maintaining the effluent silica <100 ppb and conductivity <1 µS/cm. The plant had earlier installed new high density fuel racks incorporating boron carbide silicate absorbers. The combination of chemical control limits and the silicate absorber resulted in demineralizer resin bed replacement every 50 days. This generated 650 ft^3 annually of spent resin, representing an operating cost of $390,000 per year for resin disposal and replacement.

Under the new strategy, silica was eliminated as a demineralizer control limit. Water clarity and control of aggressive ions, e.g., sulfate, chloride and nitrate, became the principal control parameters.

Implementation of the new operating philosophy reduced the fuel pool waste generation from 650 ft^3 to 90 ft^3 per year. This represented an operating cost savings of $330,000. Over the remaining life of the plant, the new program is estimated to save the utility $5,900,000. Key data taken from a 330 day demineralizer service run is presented in the figures below.

Figure 7-1 Demineralizer Effluent Conductivity μS/cm

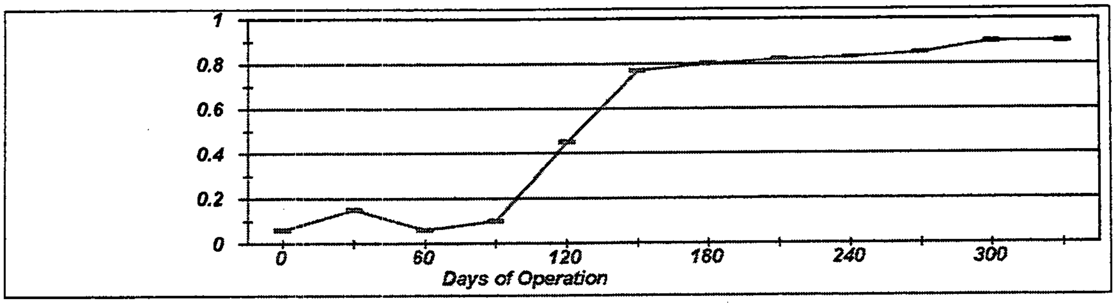


Figure 7-2 Demineralizer Effluent Silica ppb

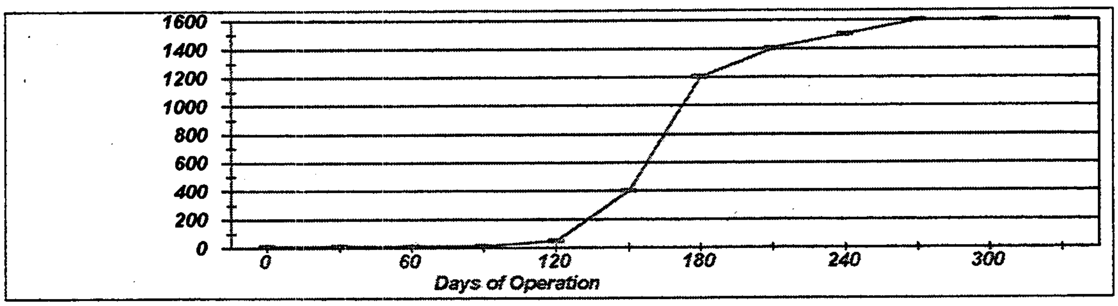
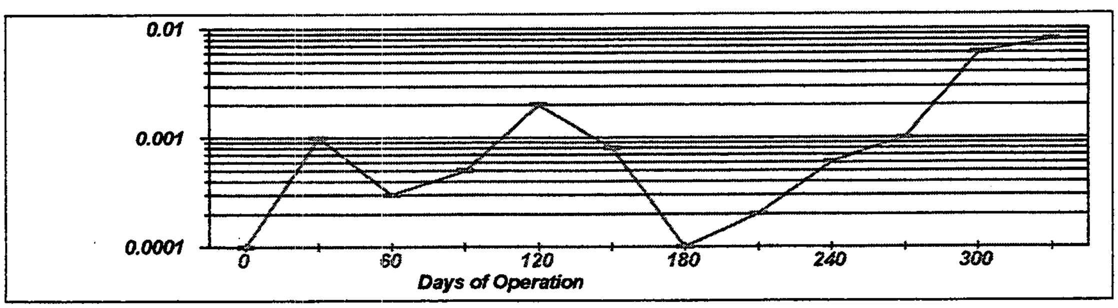


Figure 7-3 Fuel Pool Activity mci/ml



Note that the demineralizer effluent break through for silica and conductivity was experienced at 90 to 120 days. At the end of the service run, the conductivity was 0.9 μS/cm and the silica was approximately 1,600 ppb. During the major portion of the cycle the fuel pool activity fluctuated in the range of 1 E-04 to 1 E-03. At the end of the service run the pool water activity had reached a value of 8 E-3. Throughout the service run aggressive ions were maintained below their control limit of <100 ppb.

6. Eliminate the use of full time demineralization, using it only as necessary to control ***aggressive ion impurities*** to acceptable levels.

7. Operate the fuel pool filter as required to maintain water clarity.

7.5.3.3 Cross Reference(s):

Appendix A - Reference(s):

1. The EPRI document titled "Radwaste Desk Reference, Volume 3".
2. The EPRI document titled "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. The EPRI document titled "The Nature and Behavior of Particulates in PWR Primary Coolant".
4. An Illinois Water Treatment Ion Exchange Class document titled "Ion Exchange For the Power Industry".
5. An industry paper titled "An Overall Crud Reduction Program for Deep Bed Polishers in BWR Nuclear Plants".
6. An industry paper titled "Relevance of Silica in Fuel Pool Purification".

Appendices

Appendix A - Cross References to Other Resources

1. EPRI, 1994, "Radwaste Desk Reference, Volume 3 Part 1: Processing Liquid Waste", NP-7386 V3P1.
2. EPRI, 1993, "Sourcebook on Ion Exchange for Liquid Radwaste Treatment - Materials, Systems and Operations".
3. EPRI, 1996, "waste***WORKS***: Wet Computer Code".
4. EPRI, 1995, "Cost-Effective Liquid Processing Programs", TR-105859.
5. U.S. DOE, 1992, "Guidelines for Mixed Waste Minimization", DOE/LLW-144.
6. EPRI, 1995, "Radwaste Desk Reference Volume 4: Mixed Waste", EPRI NP-7386-V4.
7. EPRI, 1996, "Filter Demineralizer Performance Improvement Program".
8. EPRI, 1991, "Proceedings; Second Workshop on Condensate Polishing with Powdered Resin".
9. EPRI, 1997, "Preventing Biogassing in Low Level Waste, an Interim Report".
10. "Reactor Water Cleanup Systems, a Comprehensive Summary of Design, Corrective Actions and Improvements"; 1987, Walter W. McNeil - Detroit Edison.
11. "A Case Study of the Use of Non-Precoat Filters in BWR Condensate Polishing: Full Unit Results"; Joan Bozeman - Carolina Power and Light Brunswick Station, Rich Kohlmann - CENTEC XXI.
12. BWR Owners Group on Condensate Polishing - Deep Bed and Filter Demineralizers.
13. EPRI, 1987, "BWR Normal Water Chemistry Guidelines", NP-4946-SR.
14. EPRI, 1989, "The Nature and Behavior of Particulates in PWR Primary Coolant", NP-6640.
15. U.S. Nuclear Regulatory Commission Regulatory Guide 1.56, 1978, "Maintenance of Water Quality in Boiling Water Reactors", Revision 1.
16. Illinois Water Treatment Ion Exchange Class, "Ion Exchange For the Power Industry".
17. "An Overall Crud Reduction Program for Deep Bed Polishers in BWR Nuclear Plants", presented February 1991, by Eli Salem and Michael O'Brien.
18. "Dowex Resins - BWR Condensate Polishing", presented February 1991, BWROG Condensate Polishing Conference, New Orleans, LA
19. "Relevance of Silica in Fuel Pool Purification", Michael D. Naughton, CENTEC XXI, Carol Hornibrook, EPRI, Brian P Lunn, Boston Edison
20. EPRI, 1997, "Analyzing Advanced Liquid Waste Minimization Techniques at a PWR: Advanced Media, Pleated Filters, and Economic Evaluation Tools".
21. EPRI, 1995, "Spent Resin Disposition-Available Alternatives and Selection Analysis", TR-105901.
22. "Mixed Waste Prevention Through Chemical Control Programs, Chemical Use Review Board", presented July 1997 by John Carlson, American Electric Power.
23. EPRI, 1996, "Liquid Waste Processing at Commanche Peak", TR-106928.

24. "Reduced Particulate and Colloidal Cobalt Activity in Liquid Radwaste" James, C.C. Miller, Waste Management '91, Tucson, AZ, 1991.
25. EPRI, 1996, "Steam Generator Blowdown Demineralizer Cost Reduction Process Options", TR-107199.
26. "Liquid Radwaste Minimization Where we were, where we are, where we are going", Proceedings: 1995 EPRI International Low-Level Waste Conference, TR-105569, Orlando, Fl.
27. EPRI, 1993, "Condensate Polishing Guidelines for PWR and BWR Plants", TR-101942.
28. EPRI, 1992, "New Technology in Condensate Polishing", TR-100757.
29. EPRI, 1988, "Pretreatments and Selective Materials for Improved Processing of PWR Liquid Radioactive Waste", NP-5786.
30. "The Application of Polyelectrolyte to Improve Liquid Radwaste Treatment System Radionuclide Removal Efficiency", WA Homyk, MJ Spall, JN Vance, EPRI Radwaste Seminar, Boulder, CO, 1990.
31. EPRI, 1987, "In-plant Testing of Radwaste Ion Exchange Materials", NP-5099.
32. EPRI, 1991, "EPRI Guide to Managing Nuclear Utility Protective Clothing Programs", NP-7309.
33. EPRI, 1997, "Low Level Waste Characterization Guidelines",RS-107201.

Appendix B - Radwaste Program Impact Awareness

The following pull-out sections are for use by LRW program managers. They are designed to be used as tools for increasing station department manager's knowledge of their program's impact on LRW processing.

Organization: Senior Management

Objective	Reference Section
1. Visible management support.	**Executive Summary - 2** 3.4, 3.5, 3.8
♦ Clear and challenging goals and objectives.	
◊ Benchmark performance.	3.3, 3.4
◊ **Station** goals.	3.2, 3.5, 3.9
◊ Integrate goals between station organization.	3.5
◊ Communicate goals to station personnel.	3.3, 3.7, 3.5, 5.7
2. Front end management.	
♦ Work/outage planning.	3.9,4.5,5.7
♦ Aggressive leak control program.	4.2, 4.4
♦ Aggressive waste segregation program.	4.3,4.8,5.3,5.5, 5.6,6.2
♦ Good housekeeping.	3.10
♦ Source term reduction.	3.11
3. Comprehensive performance monitoring program.	
♦ Equipment performance.	3.3,3.10
♦ Goals.	3.2,3.3,3.4
♦ Key support programs (work/outage planning, leak reduction, housekeeping).	3.10,4.4,4.5,5.7
♦ Source term reduction.	3.11

Organization: Station Management

Objective	Reference Section
4. Evaluate station goals relative to liquid processing.	2, 3.2, 3.5
5. Station awareness.	3.7, 3.5
♦ Communication and support.	
◊ Verbal.	
◊ Written.	
◊ Visual.	
♦ Goal review with other organizations.	
6. Program costs.	3.6, 3.4, 2.3, 2.4
♦ Liquid radwaste processing.	
♦ Wet radwaste packaging and disposal.	
♦ Impact on resources.	
♦ Industry organization impact.	
7. Corporate interface and support.	2, 3.4, 3.5
8. Feedback mechanism.	3.3, 3.4, 3.7, 5.7

Organization: Maintenance

Objective	Reference Section
1. Evaluate goals potentially impacting liquid processing.	3.2, 3.5, 3.9
2. Training.	3.8
♦ Initial trade/craft specific session.	
♦ Brief annual refresher tied to routine trade specific sessions.	
♦ Video.	
3. Liquid influent quantity.	4
♦ Leak repair prioritization.	4.4
◊ Design seal leak-off versus actual and affect of run-in.	
◊ Live load packing.	
◊ Improved pump seals - particularly applicable to acid and caustic systems.	
♦ System draining.	4.2, 4.3, 4.5, 4.8, 4.10
4. Impact of "reworks".	4,5
5. Liquid influent quality.	5
♦ Oil and hydraulic fluid addition and changeout.	5.10
♦ Chemical solvents and cleaners.	5.2
♦ Precipitation and groundwater.	5.12
6. Feedback mechanism.	3.3, 3.4, 3.7, 5.7

Organization: Operations

Objective	Reference Section
1. Evaluate goals potentially impacting liquid processing.	3.2, 3.5, 3.9
2. Training.	3.8
♦ Initial session.	
♦ Brief annual refresher tied to routine training sessions.	
♦ Video.	
3. Liquid influent quantity.	4
4. Leak identification and repair prioritization.	4.4
5. Design seal leak-off versus actual and affect of run-in.	4.4
♦ System draining.	4.3, 5.3
♦ Liquid processing system media handling.	4.7
♦ Identifying influent perturbations.	4.2
♦ System flushing.	4.3, 4.9, 4.10
6. Liquid influent quality.	5
♦ Oil and hydraulic fluid addition.	5.10
♦ Waste liquid processing media handling.	5.8
♦ Chemical solvents and cleaners.	5.2
♦ Closed cooling and fire protection system draining.	4.3, 4.10
♦ Identifying influent perturbations.	4.2
♦ System flushing.	4.3, 4.8, 4.10
7. Feedback mechanism.	3.3, 3.4, 3.7, 4.7, 5.7

Organization: Chemistry

Objective	Reference Section
1. Evaluate goals potentially impacting liquid processing.	3.2, 3.5, 3.9
2. Training.	3.8
♦ Initial session.	
♦ Brief annual refresher tied to routine training sessions.	
♦ Video.	
3. Liquid influent quantity.	4.9
♦ Sample sink waste disposition.	
♦ Sample lab waste disposition.	
♦ Use of sample lab sinks and small demineralized water units.	
♦ Liquid processing media rinsing and flushing.	
♦ Liquid waste effluent release and recycle criteria impact and evaluation.	
4. Liquid influent quality.	5
♦ Chemical analysis waste and alternative analytical procedures.	5.15
♦ Chemical control program - evaluation of impact on liquid processing media and operations.	5.2
♦ Influent characterization.	5.4
5. Feedback mechanism.	3.3, 3.4, 3.7, 5.7

Organization: Training

Objective	Reference Section
1. Use of organization/trade specific liquid radwaste impact training modules.	3.8
♦ Tied to specific tasks or evolutions.	
2. Developing and implementing the use of a generic video for non radwaste organizations.	3.8
3. Review of radwaste processing operations for potential system operator training enhancements.	3.3, 3.4, 3.7, 4.7, 5.7
4. Qualification program maintenance.	3.8
♦ Plant organization input.	3.4, 3.5
♦ Equipment/material vendor input to optimize performance.	
5. Feedback mechanism.	3.3, 3.4, 3.7, 4.7, 5.7

Organization: Radiation Protection

Objective	Reference Section
1. Evaluate goals potentially impacting liquid processing.	3.2, 3.5, 3.9
2. Training.	3.8
♦ Initial session.	
♦ Brief annual refresher tied to routine training sessions.	
♦ Video.	
3. Liquid influent quantity.	4
♦ Identification of leaking components.	4.2, 4.4
♦ ALARA line and component flushing.	4.3, 4.10
♦ Use of alternates to processing.	4.8
♦ Spent liquid waste processing media sluice evolutions/line flushing.	4.7
4. Liquid influent quality.	5
♦ Use and maintenance of drain socks.	5.3
♦ Identification of influent perturbations.	5.4
5. Solid waste generation.	
♦ Dose rate limitations on liquid waste processing media changeout versus cost benefit analysis.	3.11, 6.3, 6.5, 6.7, 6.8, 6.9, 7.3
6. Feedback mechanism.	3.3, 3.4, 3.7, 4.7, 5.7

Appendix C - Selection of "Best" Tracking, Trending and Performance Monitoring Concepts

Individual stations have specific requirements and reasons for tracking program data, therefore this appendix does not attempt to represent a recommended reporting format. It contains a compilation of the "best" segments of liquid waste processing reports from numerous stations. It is intended to illustrate varying strategies for tracking, trending, and reporting liquid waste program statistics. The LRW program manager should review the following material and use it to enhance existing tracking and trending programs, ensuring sufficient data is tracked and trended to effectively monitor the program status.

It is equally important to consider the target audience that will be using the data in routine status reports or posted graphics. When developing the material, consider:

- The amount of detail versus required knowledge.
- The units of expression and user familiarity.
- Volume of data presented.
- Data labeled with corresponding date and time.
- Acronyms defined in key.
- Graphic representation of data.
    - Clear delineation or annotation of desired performance.
    - Adequacy of scale and labels.
    - Bar and segment schemes - ability to reproduce in black and white versus colored.

Monthly Radwaste Production Report

Monthly Summary			
	Last Month	This Month	Trend
This Month RCA Influent (GPD)	2,070.0	1,644.1	↘
Radioactive Discharges (GAL)	101,610	50,968	↘
This Month Ci Released (Gamma)	0.010	0.006	↘
This Month Dose To Public (Gamma)	4.00E-04	2.16E-06	↘
This Month % Reg. Limit (Gamma)	6.40E-03	1.00E-04	↘
Non-Radioactive Discharges (GAL)	2,253,254	937,582	↘
Overall Trend			↘

MONTHLY RADWASTE PRODUCTION REPORT
DECEMBER 1996

I. Radioactive Liquid Waste Management Systems

A. Radioactive Influents

1. RCA FLOOR DRAINS AND SUMPS GOAL ≤ 4320 GPD

WASTE STREAMS				
	MONTH GAL	MONTH GPD	YTD GAL	YTD GPD
UNIT 1 CONTAINMENT[1]	1,232	39.7	44,605	121.9
UNIT 1 FLOOR DRAINS*	39,587	1,277.0	523,429	1,430.1
UNIT 2 CONTAINMENT	624	20.1	40,664	111.1
UNIT 2 FLOOR DRAINS	7,225	233.1	75,475	206.2
WASTE HOLDUP TANK	2,300	74.2	50,274	137.4
TOTALS	50,968	1,644.1	734,447	2,006.7

* INCLUDES COMMON SYSTEMS

2. AUXILIARY WASTE STREAMS

AUXILIARY WASTE STREAMS				
	MONTH GAL	MONTH GPD	YTD GAL	YTD GPD
BORON RECYCLE SYSTEM	18,500	596.8	1,142,500	3,121.6
CO-CURRENT WASTE SYSTEM	0	0.0	257,896	704.6
TOTALS	18,500	596.8	1,400,396	3,826.2

B. Water Recovered Back to Plant Systems

Recovered Water Totals		
	Month Gallons	Year to Date Gallons
To Boric Acid Storage Tank	0	0
To RWST, RCS and/or SFP[2]	27,000	515,000
Total	**27,000**	**515,000**

MONTHLY RADWASTE PRODUCTION REPORT

DECEMBER 1996

C. Radioactive Effluents to Squaw Creek   Goal: < 2.5 Million Gal

DISCHARGES TO SQUAW CREEK BY SYSTEM			
	MONTH GAL	YTD GAL	YTD % OF ANNUAL GOAL
RCA FLOOR DRAINS/SUMPS	50,968	800,728	32.0%
BORON RECYCLE SYSTEM[3]	0	739,500	29.6%
CO-CURRENT WASTE SYSTEM	0	21,056	0.8%
SPENT FUEL POOL DRAINS	0	20,000	0.8%
TOTAL[3]	50,968	1,581,284	63.3%

D. Dose Associated with all Radioactive Releases to Squaw Creek

CALCULATED DOSE ESTIMATES						
	MONTHLY CI	MONTHLY DOSE TO PUBLIC (MREM)	MONTHLY % OF REGULATORY LIMIT	YTD CI	YTD DOSE TO THE PUBLIC (MREM)	YTD % OF REGULATORY LIMIT
GAMMA	0.006	0.0000	0.0001	0.144	0.0005	0.0081
TRITIUM	56.300	0.0064	0.1058	986.000	0.0793	1.3213
TOTALS	56.306	0.0064	0.1059	986.144	0.0798	1.3294

Goal < .10% of Regulatory Limit & <.20 Ci

E. Highlights and Unusual Events

1. Following 1RF05 U1 containment leakrate has dropped significantly to <40 gallons per day. This is well below the outage goal of <100 gpd.

2. RHUT water was recovered back to the SFP system this month.

3. Leak reduction in the plant has led to RHUT volumes constituting ~50% of discharged volumes. Historically it has contributed no more than 20%. Recovery of borated water has helped lower the amount of discharged volumes to ~1.6 million gallons. This is a 31% reduction over 1995. This year we have recovered ~500,000 gallons.

MONTHLY RADWASTE PRODUCTION REPORT

DECEMBER 1996

II. Solid Waste Management Systems

A. Radioactive Resins

1. RESIN VOLUMES

TRANSFERRED RESIN VOLUMES				
	THIS MONTH TO SRST	THIS MONTH TO HIC	YTD TO SRST	YTD TO HIC
U1 NSSS DEMINS	0	0	30.0	245.0
U2 NSSS DEMINS	0	0	60.0	227.0
COMMON	0	0	110.0	110.0
FDS	[redacted]	67	[redacted]	109.3
TOTALS	0	67	200.0	691.3

GOAL: < 750 FT^3 DISPOSAL/STORAGE

HIGH INTEGRITY CONTAINERS			
TYPE	YTD HICS CLOSED	STORAGE/DISPOSAL VOLUME (CUFT)	YTD STORAGE/DISPOSAL VOLUME (CUFT)
NUHIC 136	2	272.2	272.2
RADLOCK 179	0	0.0	0.0
RADLOCK 195	1	0.0	195.2
OTHER*[1]	2	280.0	371.0
TOTAL YTD[2]	5	[redacted]	838.4

*HIC FILLED WITH BTRS RESINS TO UNDERGO OFFSITE VOLUME REDUCTION PROCESS PRIOR TO DISPOSAL. EXPECTED VOLUME REDUCTION IS BETWEEN 3:1 AND 10:1

B. Steam Generator Blowdown Resins

1. STEAM GENERATOR BLOWDOWN RESIN VOLUMES

Annual and Monthly Totals				
	Monthly CuFt Loaded	YTD CuFt Loaded	Monthly CuFt to SRST	YTD CuFt to SRST
Unit 1 SGBD	140	840	70	700
Unit 2 SGBD	0	770	70	700
Total	**140**	**1610**	**140**	**1400**

MONTHLY RADWASTE PRODUCTION REPORT

DECEMBER 1996

C. Condensate Polisher Operation

1. POWDEX TRANSFERRED TO LVW

POWDEX VOLUMES			
	MONTH CUFT TO UPS	MONTH CUFT TO LVW	YTD CUFT TO LVW
UNIT 1 POWDEX VESSELS	0	0	420
UNIT 2 POWDEX VESSELS	0	0	504
TOTAL		0	924

2. POLISHER BED CHANGE OUTS

Polisher Bed Change Outs		
	MONTH	YTD
UNIT 1	0	15
UNIT 2	0	25
TOTAL	0	40

D. Demineralizer Performance Summary

DEMINS DEPLETED THIS MONTH				
	TRANSFERRED TO	DEPLETION DATE	GALLONS THRU	DAYS RUN
SGBD MB 2-02	SRST	DECEMBER 4, 1996	NA	40

E. Highlights and Unusual Occurrences

1. BTRS resin handling was revised this year. Rather than transfering BTRS resin to theNSSS storage tank it is instead transfered directly to a mobile container. This change allows for processing & Disposal of the waste stream at a lower cost. This year 420 FT3 were transfered to 3 containers and has been sent to an offsite processor for incineration prior to disposal. Cost evaluation associated with this will be detailed in the annual RW report.

MONTHLY RADWASTE PRODUCTION REPORT

DECEMBER 1996

III. Radioactive Waste Gas System

A. Waste Gas Decay Tank Releases

- Date of Last Discharge - 8/7/96
- Number of discharges this month - none
- Month Total Ft^3 Discharged - none
- Year to Date Discharges Ft^3 - 10,041 ft^3

B. Waste Gas Decay Tank Inventory

- Current Inventory - 24,595 ft^3
- Capacity Available - 45.56 %

C. Highlights and Unusual Events -

- Maint Drain performed on GDT-8 and GDT-10.

Monthly Radwaste Production Report

December 1996

IV. Secondary Non-Radioactive Releases to The LVW System

A. Unit Specific Releases to LVW

Waste Stream Totals to LVW				
	Month Gallons	Month AVG. GPD	Year to Date Gal	Year to Date GPD
Unit 1 TB Sump	291,480	9,402.6	6,349,200	17,347.5
Unit 1 CP Tanks	4,062	131.0	424,059	1,158.6
Unit 2 TB Sump	224,580	7,244.5	6,492,220	17,738.3
Unit 2 CP Tanks	0	0.0	640,473	1,749.9
Unit 1 SFGD	74,265	2,395.6	950,800	2,597.8
Unit 2 SFGD	13,665	440.8	331,000	904.4
Total	608,052	19,614.6	15,187,752	41,496.6

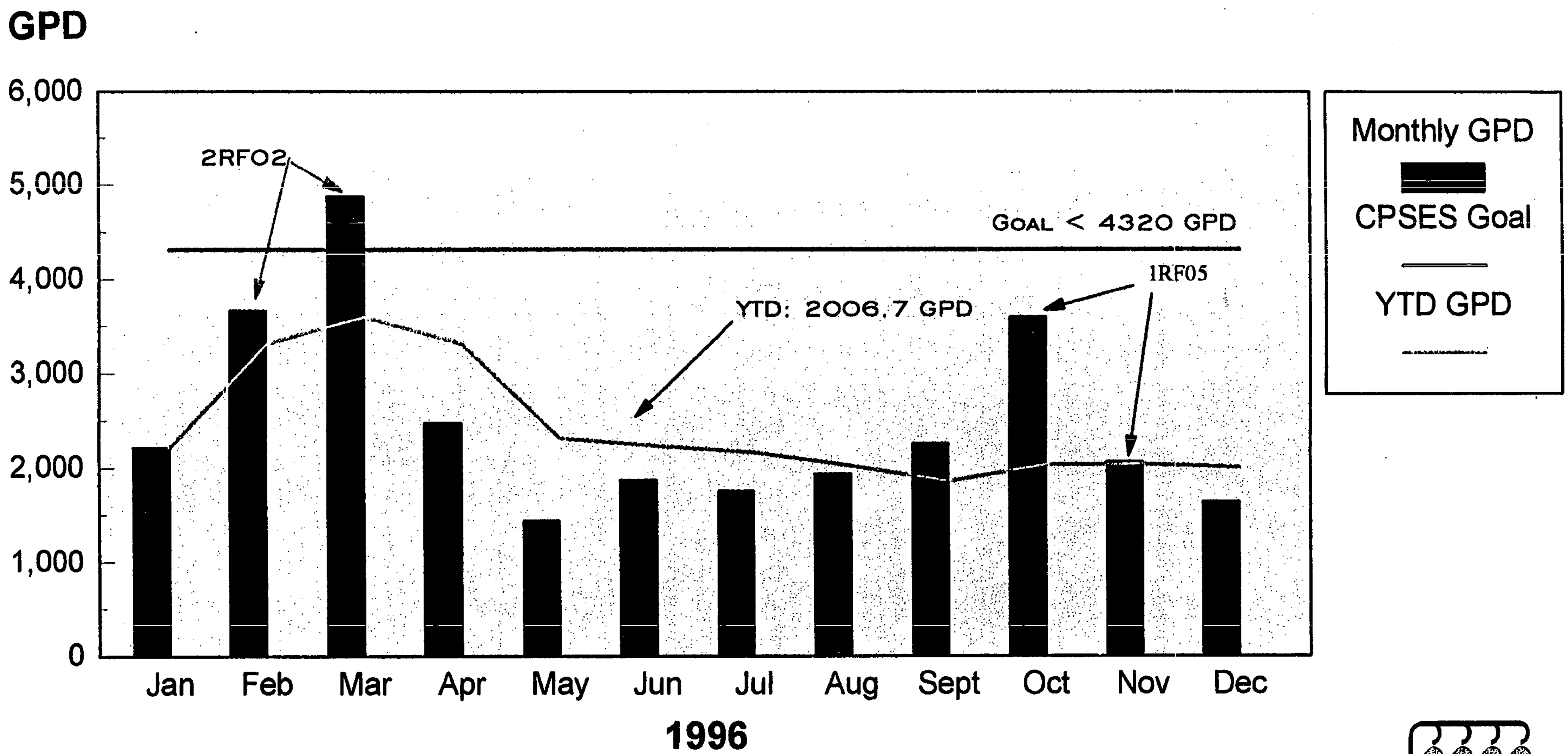
B. Common System Releases To LVW

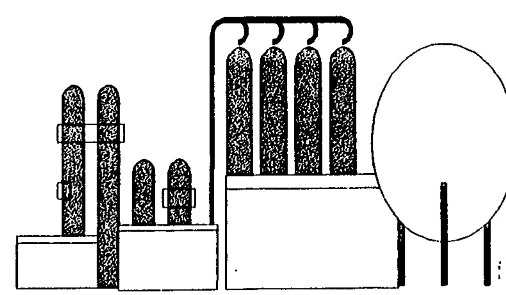
Common Waste Stream Totals to LVW				
	Month Gallons	Month AVG. GPD	Year to Date Gal	Year to Date GPD
Chemical Sump	6,525	210.5	2,562,085	7,000.2
Co-Current Waste	17,024	549.2	267,489	730.8
Aux Bld. Non-Rad	305,981	9,870.4	3,581,105	9,784.4
Total	329,530	10,630.0	6,410,679	17,515.5

C. Total Releases to LVW System

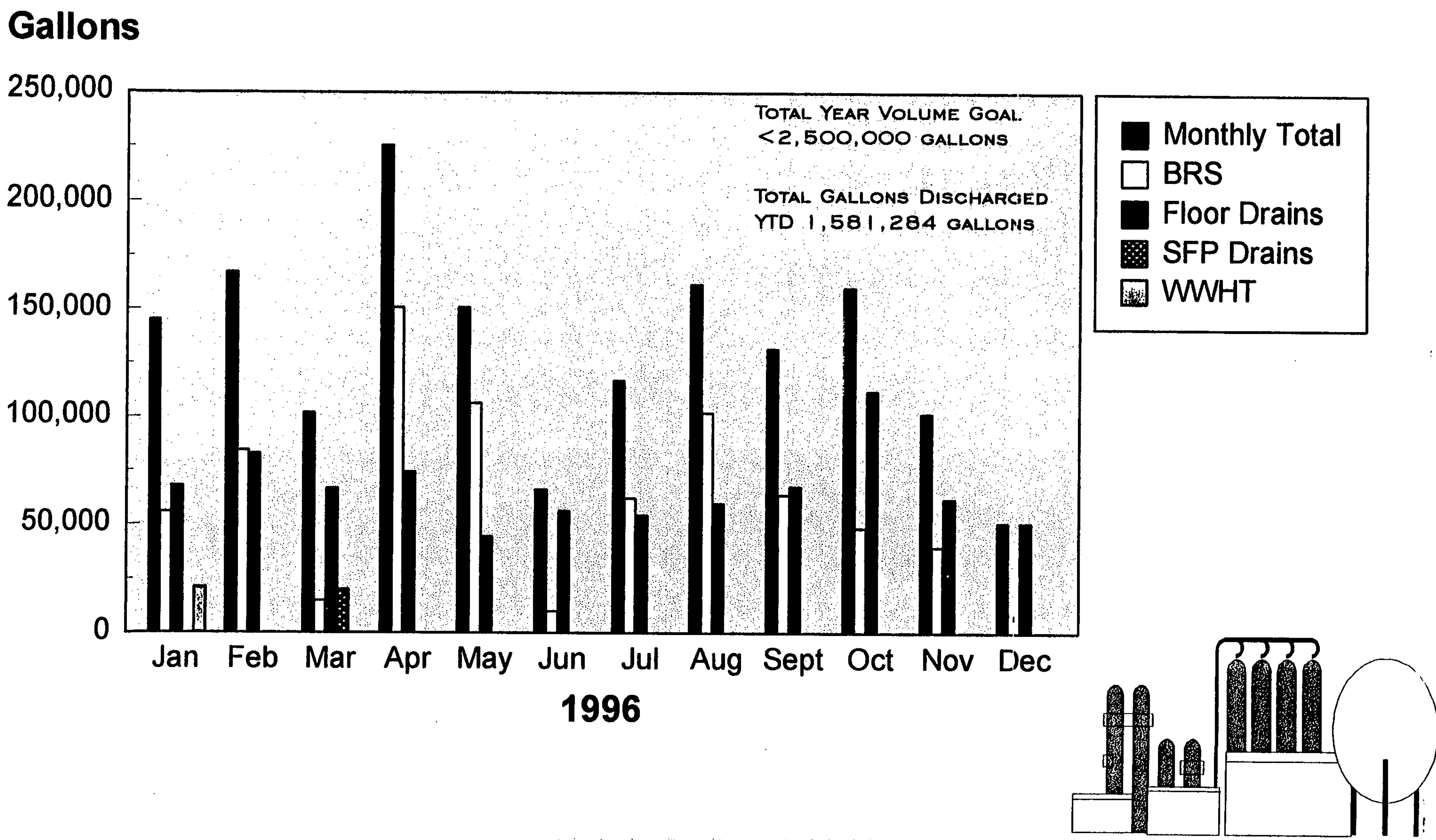
LVW Overall Totals				
	Total Gallons	Monthly GPD	Year To Date Total	Year To Date GPD
Total Releases	937,582	30,245.00	21,598,431	59,012.00

RCA Influent Rates

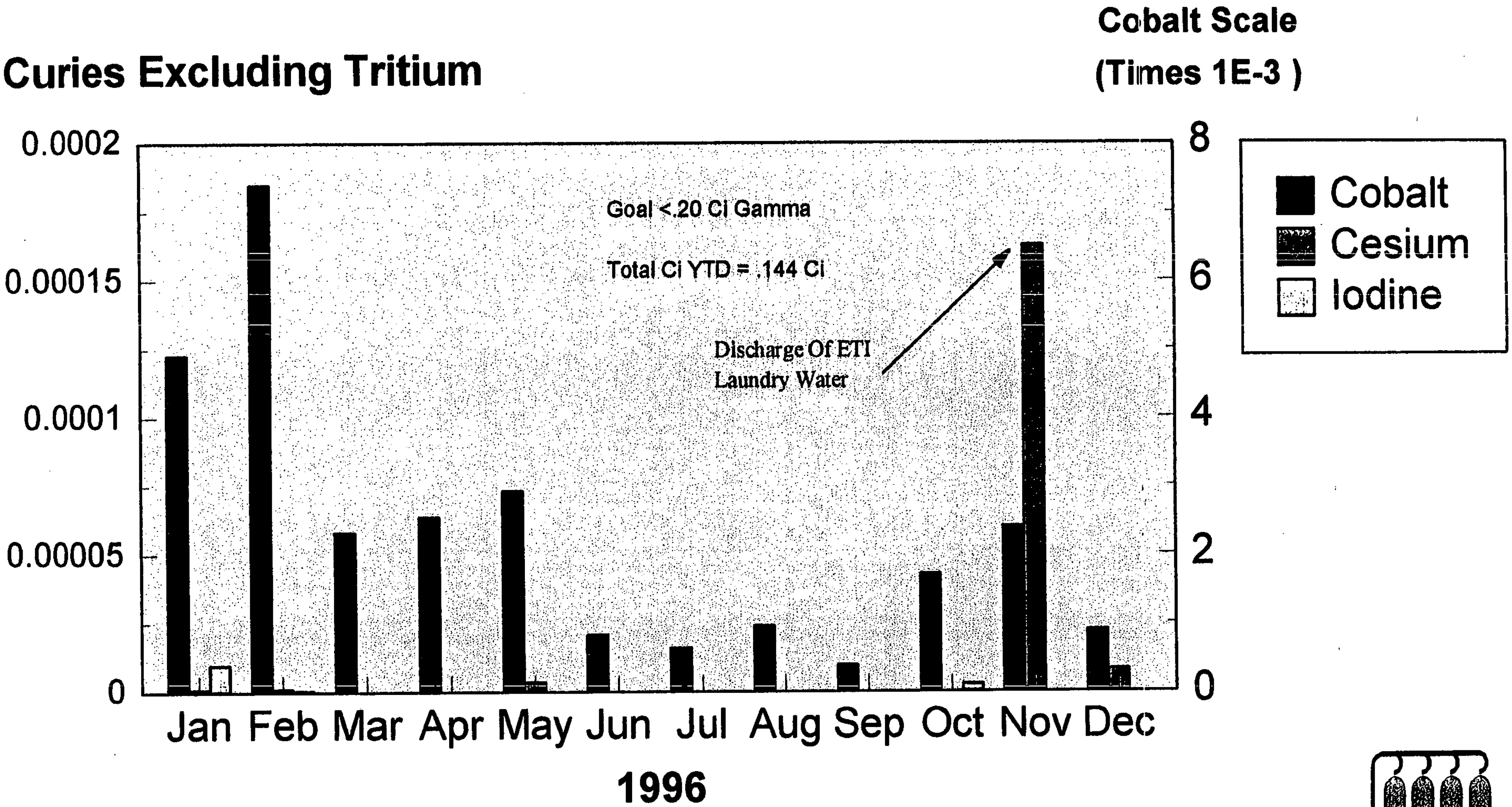


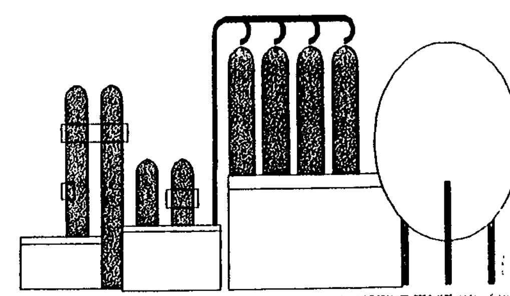


Discharges to Outfall 101

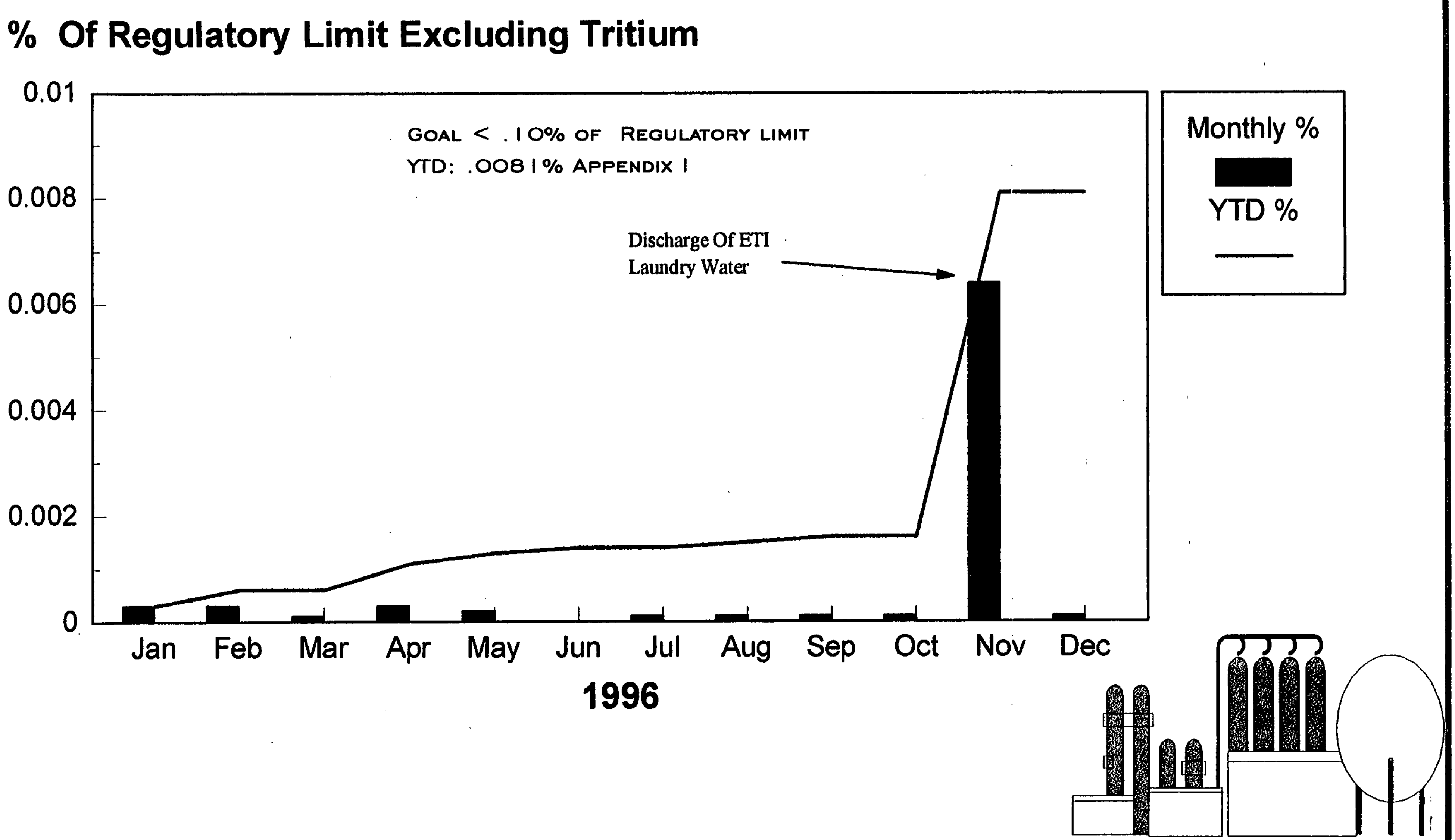


Effluents - Curies

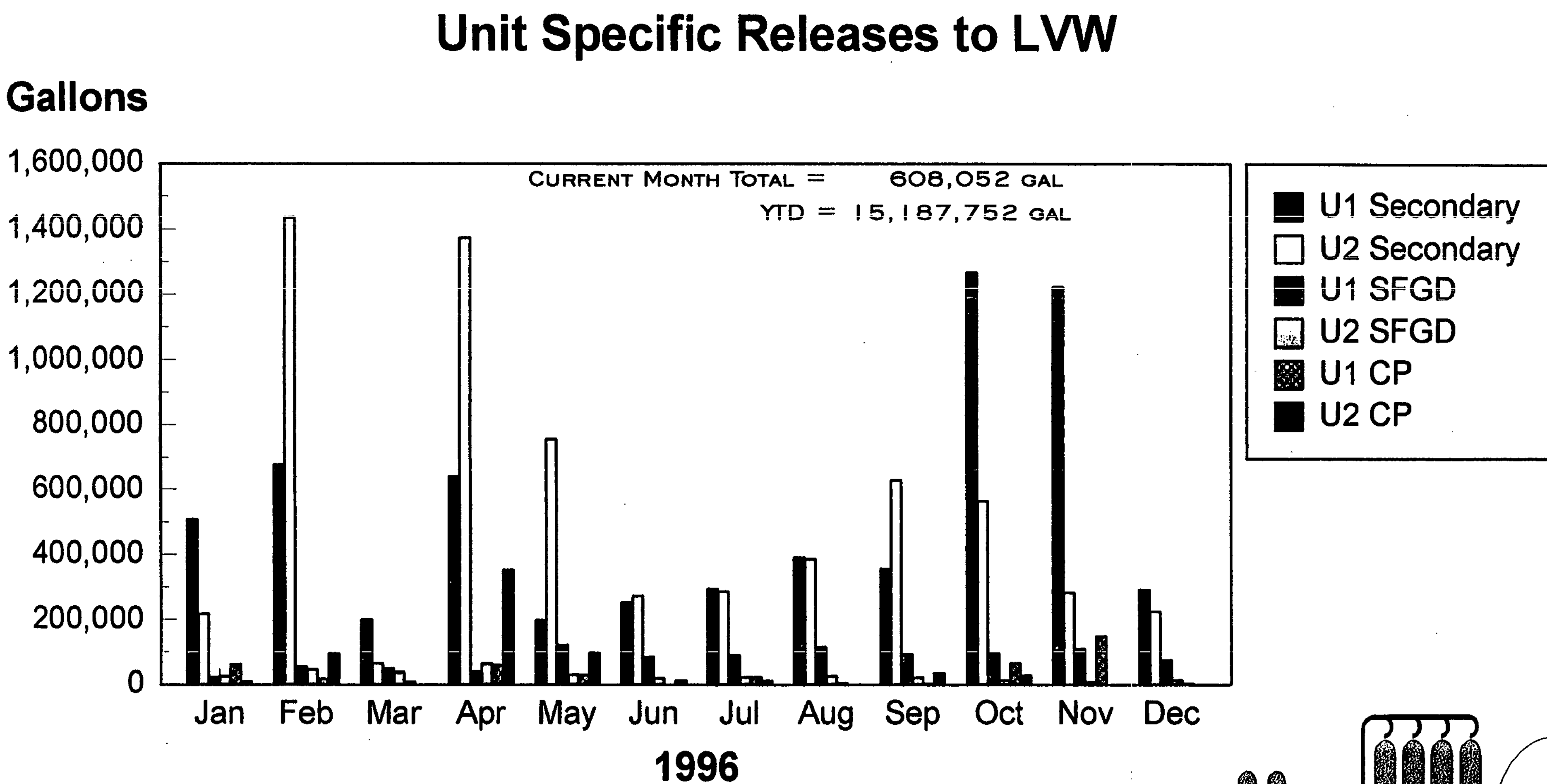


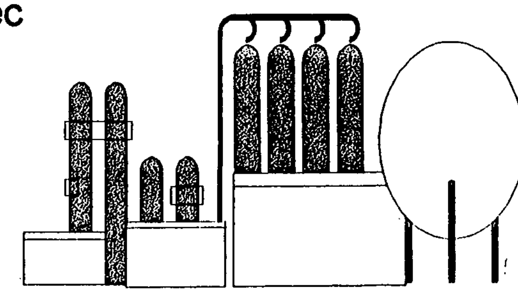


Effluents - % Appendix I

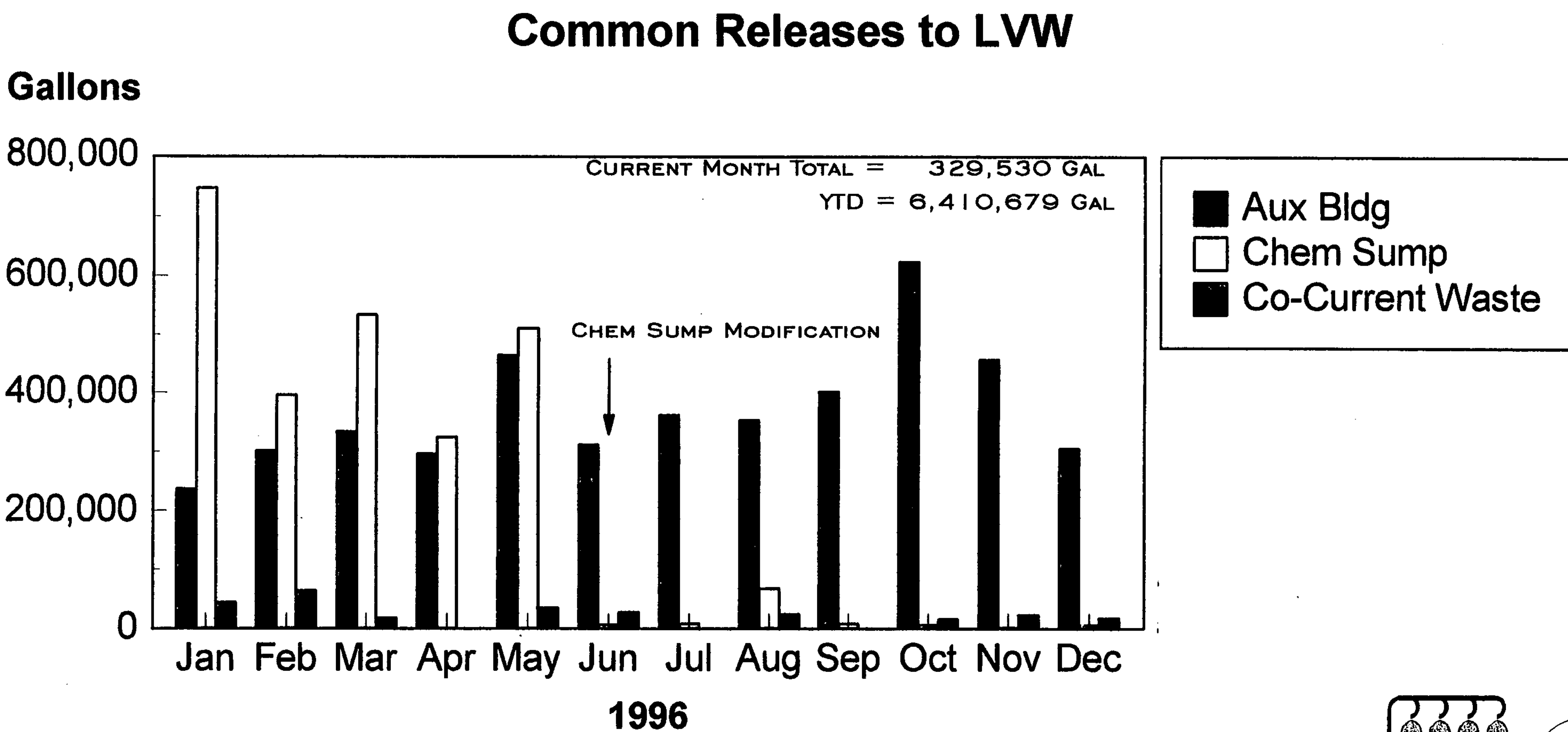


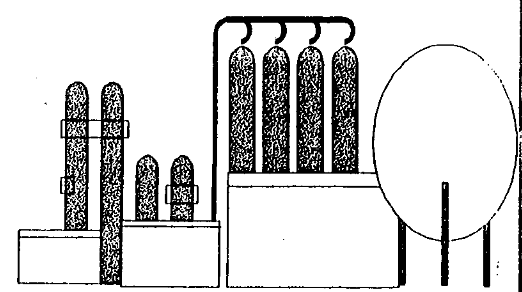
Releases to LVW





Common Releases





RADWASTE PROCESS FLOWCHART
Monthly Summary for November 1994

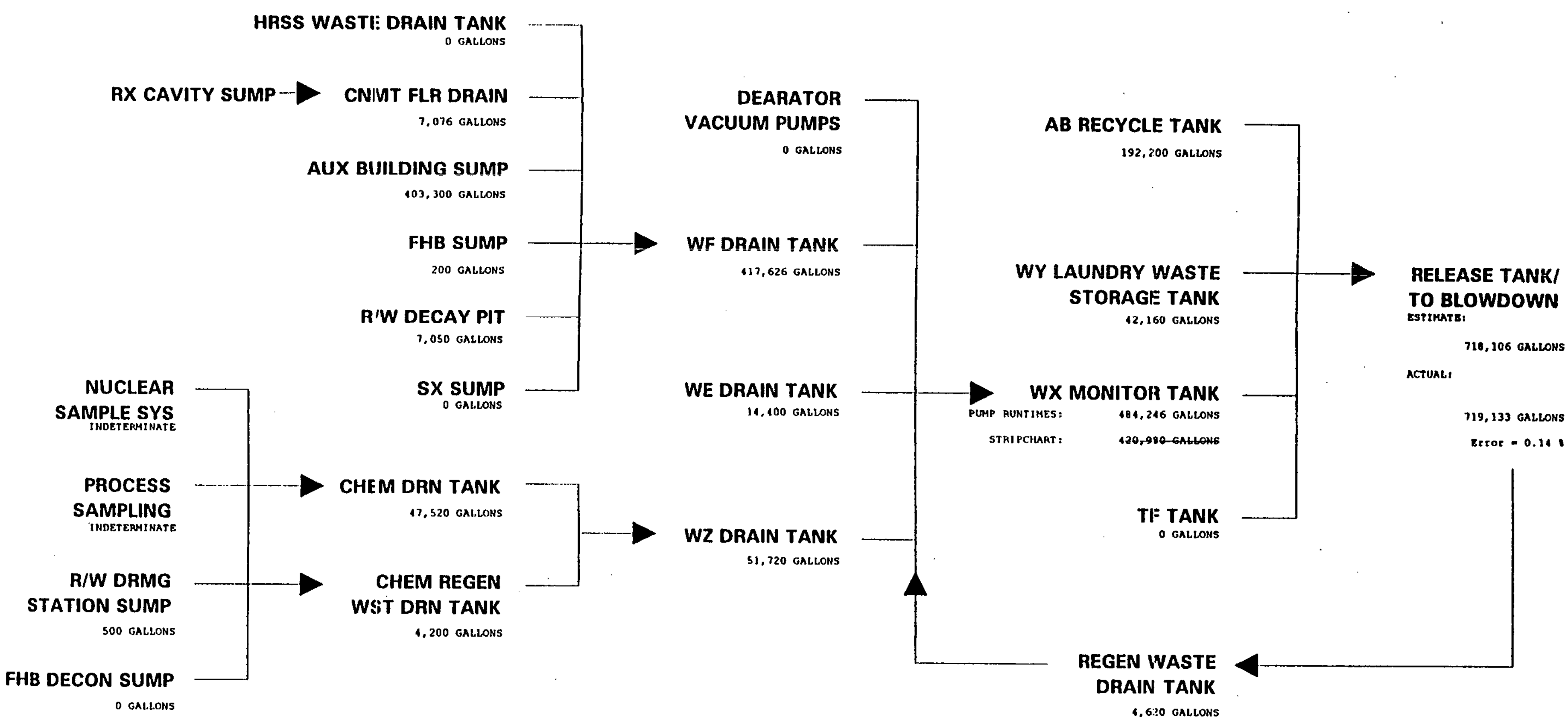
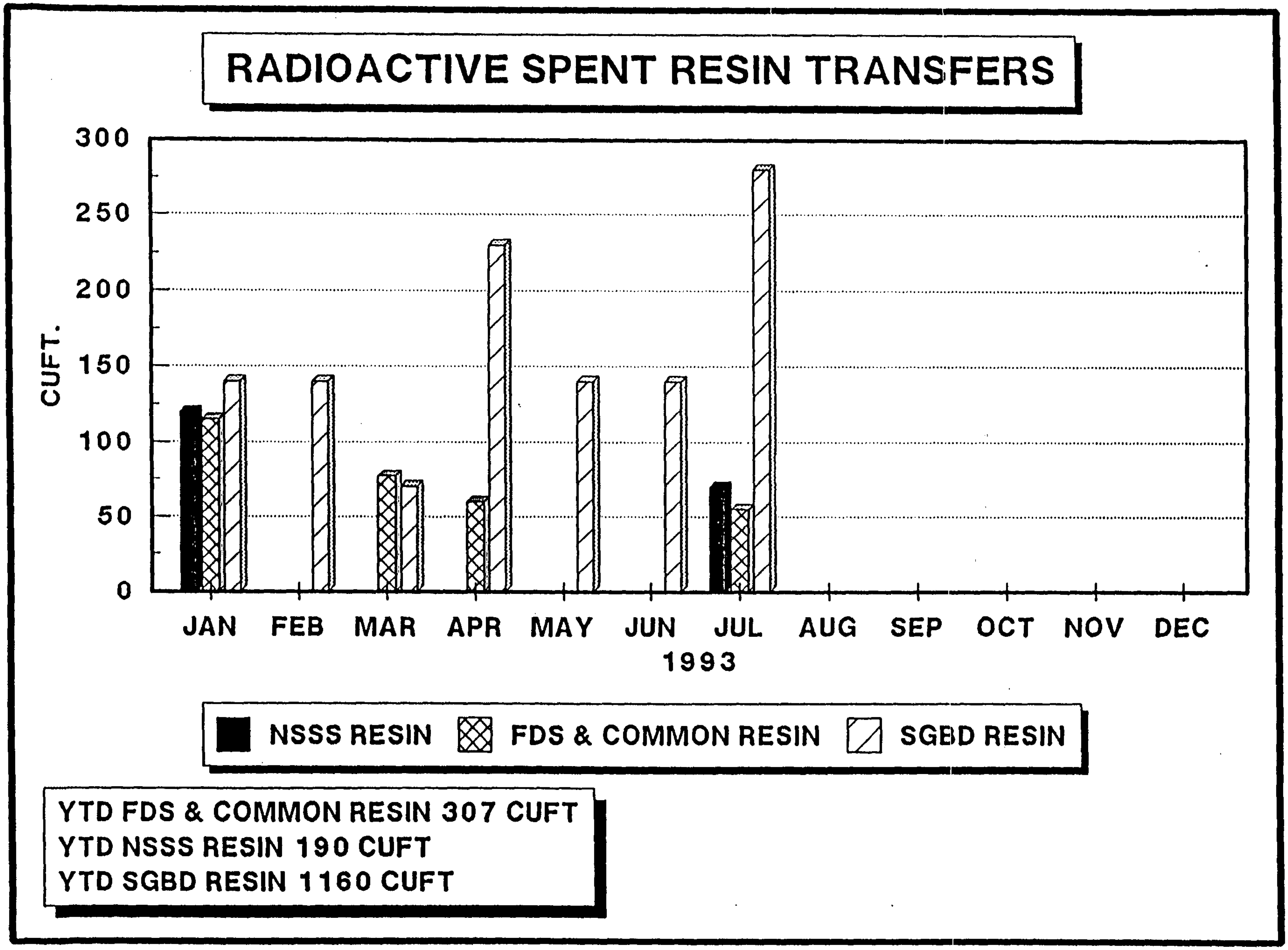
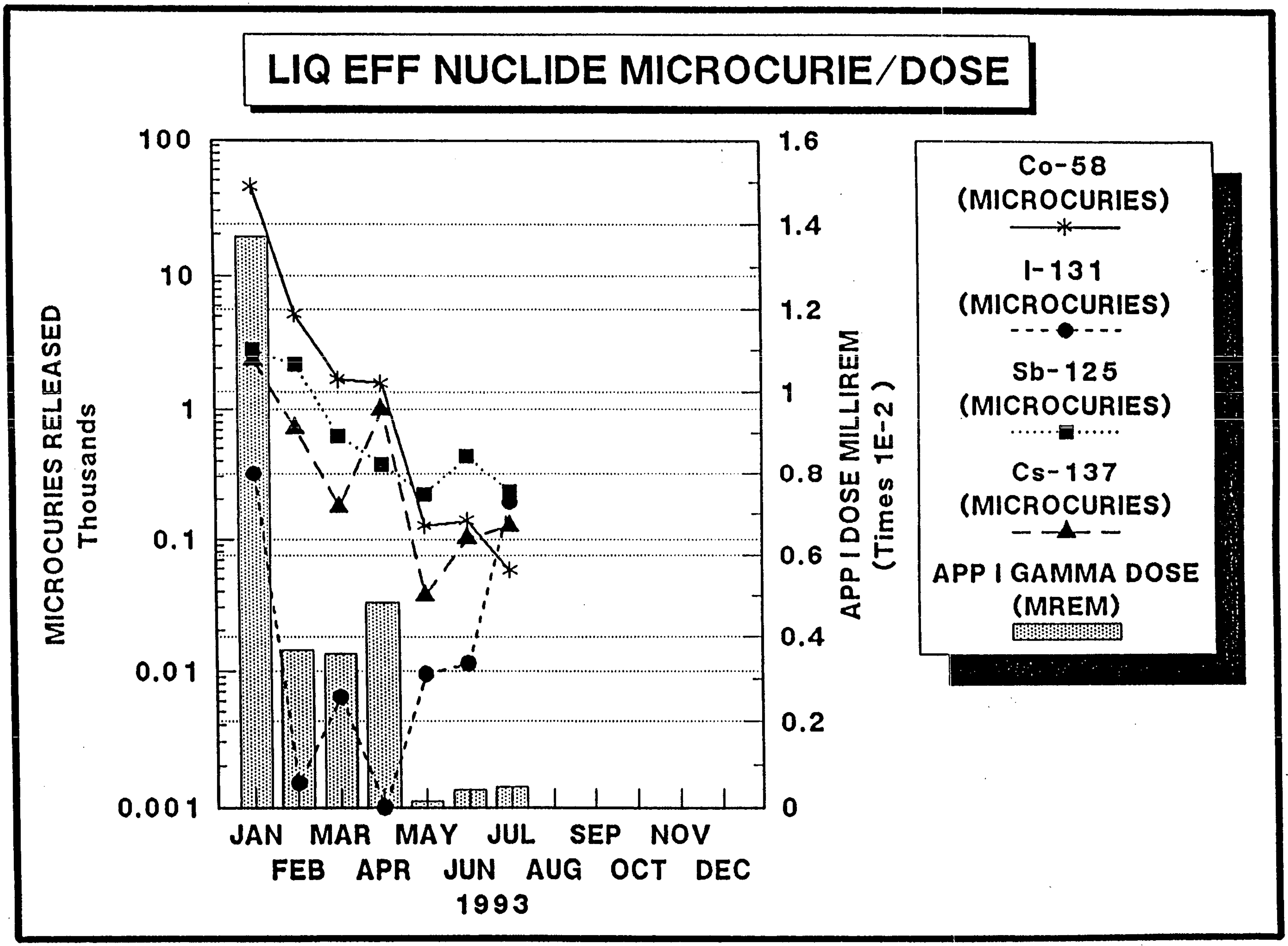


Figure 5


RADIOACTIVE SPENT RESIN TRANSFERS
300
250
200
150
100
50
0
CUFT.
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1993
NSSS RESIN
FDS & COMMON RESIN
SGBD RESIN
YTD FDS & COMMON RESIN 307 CUFT
YTD NSSS RESIN 190 CUFT
YTD SGBD RESIN 1160 CUFT


LIQ EFF NUCLIDE MICROCURIE/DOSE
MICROCURIES RELEASED
Thousands
100
10
1
0.1
0.01
0.001
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
APP I DOSE MILLIREM
(Times 1E-2)
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1993
Co-58
(MICROCURIES)
I-131
(MICROCURIES)
Sb-125
(MICROCURIES)
Cs-137
(MICROCURIES)
APP I GAMMA DOSE
(MREM)

RADWASTE MONTHLY PERFORMANCE REPORT

Radwaste Influents			
Low Conductivity - Waste Collector		1139.6	kgallons
High Conductivity - Floor Drain Collector (processed to waste collector)		318.1	kgallons
High Conductivity - Regen Waste (processed to waste collector)		51.5	kgallons
Reprocessed Water		0	kgallons
Recovered Water (to CST's)		936.0	kgallons
Discharged Water (to Lake)		178.8	kgallons
Waste Processed			
Evaporator Bottoms:	Volume	0	cu. meter
	Activity	0	Ci.
Solidified Resins:	Volume	0	cu. meter
	Activity	0	Ci.
Dewatered Resins:	Volume	0	cu. meter
	Activity	0	Ci.
Dry Active Waste (Trash):	Volume	0	cu. meter
	Activity	0	Ci.
Waste in Storage (Year to Date)			
Resins and Evap Bottoms:	Volume	62.547	cu. meter
	Activity	351.120	Ci.
Dry Active Waste	Volume	12.499	cu. meter
	Activity	93.020	Ci.
Total (all types):	Volume	75.046	cu. meter
	Activity	444.140	Ci.

RADWASTE MONTHLY PERFORMANCE REPORT (cont)

Disposed Waste (Month)

Resin and Evap Bottoms:	Volume	0	cu. meter
	Activity	0	Ci.
Dry Active Waste:	Volume	0	cu. meter
	Activity	0	Ci.
Total:	Volume	0	cu. meter
	Activity	0	Ci.

Disposed Waste (Year to Date)

Resins and Evap Bottoms:	Volume	0	cu. meter
	Activity	0	Ci.
Dry Active Waste:	Volume	0	cu. meter
	Activity	0	Ci.
Total:	Volume	0	cu. meter
	Activity	0	Ci.

Off Site Processing/Disposal (Month)

Resins:	Volume	0	cu. meter
	Activity	0	Ci.
Dry Active Waste:	Volume	5.1225453	cu. meter
	Activity	0.1350777	Ci.
Total:	Volume	5.1225453	cu. meter
	Activity	0.1350777	Ci.

Off Site Processing/Disposal (Year to Date)

Resins:	Volume	0	cu. meter
	Activity	0	Ci.
Dry Active Waste:	Volume	5.1225453	cu. meter
	Activity	0.1350777	Ci.
Total:	Volume	5.1225453	cu. meter
	Activity	0.1350777	Ci.

Total of Waste in Storage + Disposed Waste	80.16826	cu. meter
+ Off Site Processed Waste =	444.27508	Ci.

AUGUST - 1995

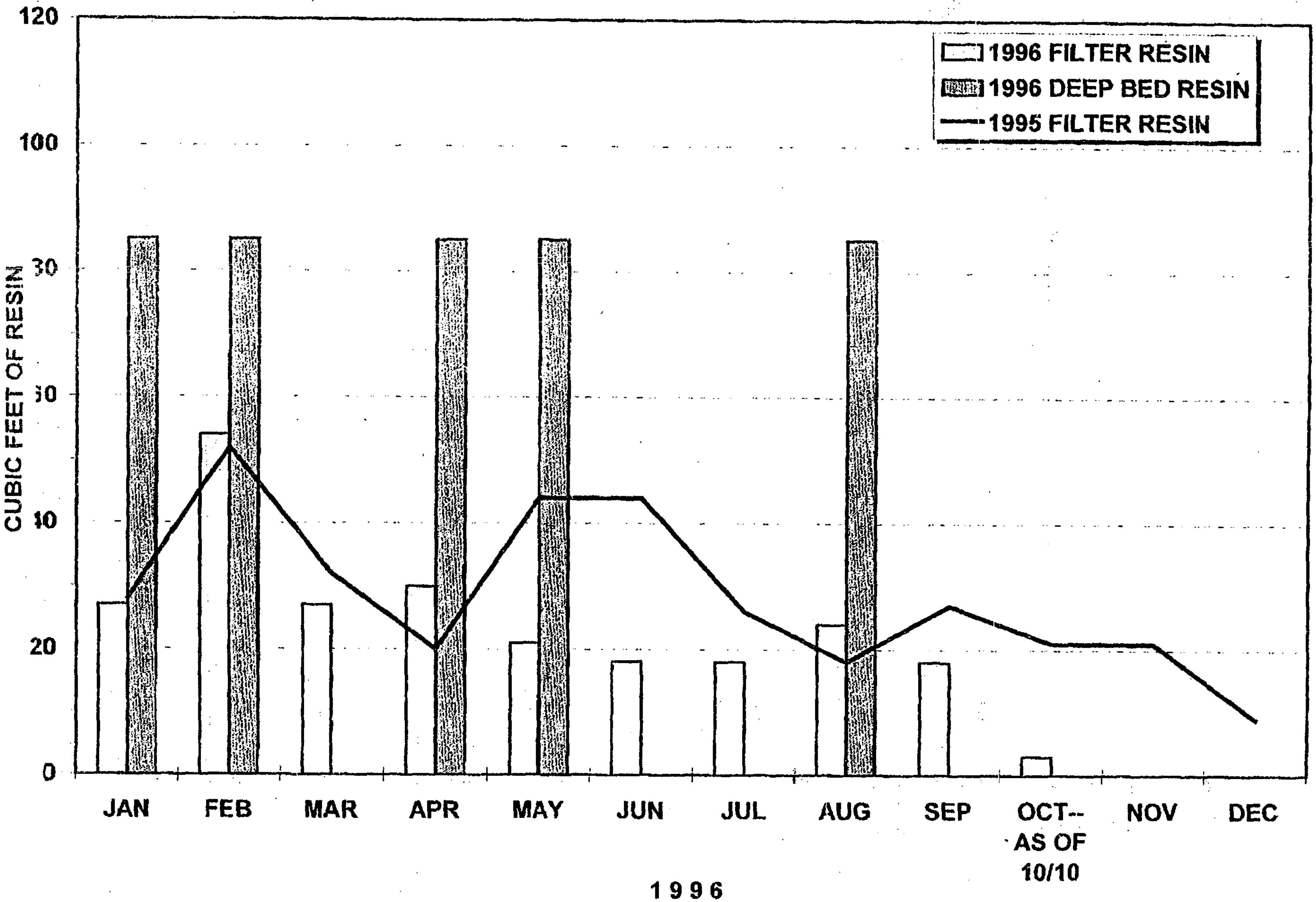
MONTHLY TANK SUMMARY

DAY	WC	RP	RS	RP	LAKE	RW	RP	FD	RP	WD	RP	CST
1	33.0		44.8									
2	52.5		45.1					21.0				47.6
3	18.2		23.7									
4	34.6							2.9				
5	40.8		23.5					18.3		23.8		
6	21.1											23.8
7	32.3		44.7					17.6				22.5
8	30.7		26.4					3.8				
9	29.4											
10	30.5							19.1				23.6
11	25.2							2.1				
12	57.2		47.4					21.2				
13	41.6		47.4									
14	11.6		23.7					15.1				
15	47.5		47.4					11.0				
16	84.7		23.7			4.4		29.6		47.6		
17	41.1		47.4					8.3		23.8		23.8
18	61.0		23.7									
19	20.5		23.7									
20	47.6		17.7					28.1				
21	20.5		23.7					14.3				47.6
22	58.3		23.7					38.9				
23	31.7		23.7					3.0				
24	31.7					10.0						
25	41.2		47.4			16.0		17.8				
26	53.6		47.4			21.1		10.9				
27	46.7		64.6					13.7				
28	19.3		6.3									
29	21.2									32.4		
30	30.6							21.4		15.2		
31	23.7				36							
TOTALS:	1139.6	0.0	747.1	0.0	36.0	51.5	0.0	318.1	0.0	142.8	0.0	188.9

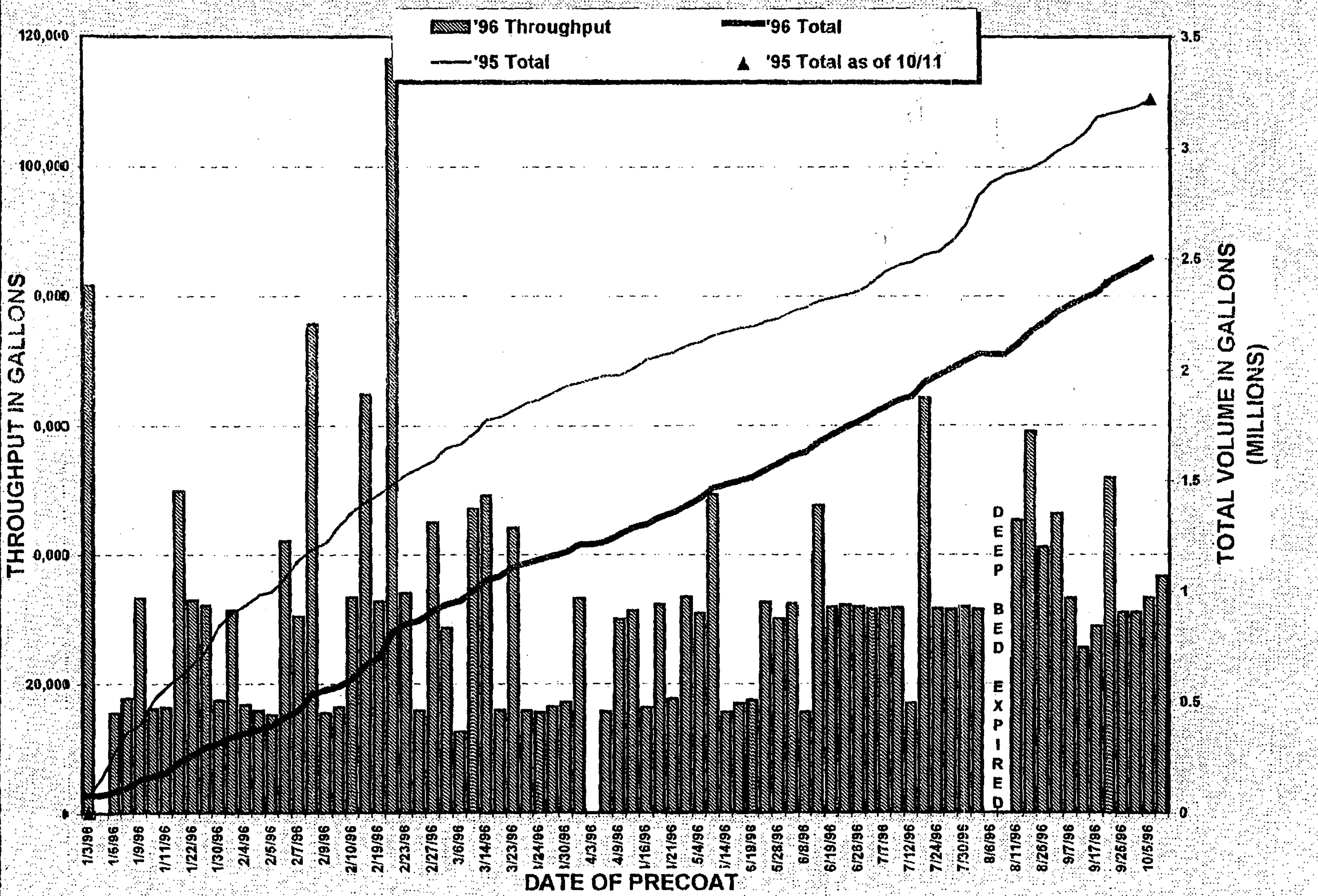
TOTAL INFLUENT (WC):	1139.6
TOTAL RECOVERED (RS+CST):	936.0
TOTAL DISCHARGED (WD+LAKE):	178.8
TOTAL REPROCESSED (RP):	0.0

NOTES
1. ALL NUMBERS ARE K GALLONS
2. WC-WASTE COLLECTOR
3. RP-REPROCESSED
4. RS-RECOVERY SAMPLE
5. RW-REGEN WASTE
6. FD-FLOOR DRAINS
7. WD-WASTE DISCHARGE

FLOOR DRAIN MONTHLY RESIN USAGE



FLOOR DRAIN FILTER/DEMIN THROUGHPUT



S:\WAD\1_EXCEL\PERFORMANCE DATA.XLS

P. J. [signature] 9/8/93

Form Approved by Effective Date

UNIT 1 OPERATIONS

WEEKLY RADIOACTIVE WASTE WEEKLY

Week ___________

TANK	NUMBER OF DISCHARGES	GALLONS DISCHARGED	CURIES DISCHARGED
Floor Drain Sample Tanks			
Waste Sample Tanks			
Decon Solutionn Tank			
	TOTAL		

Comments:

____

____

____

____

____

____

TREND REPORTS

Attach trend graphs of collection sumps, explain reason for any abnormally high trends.

____

____

____

____

____

____

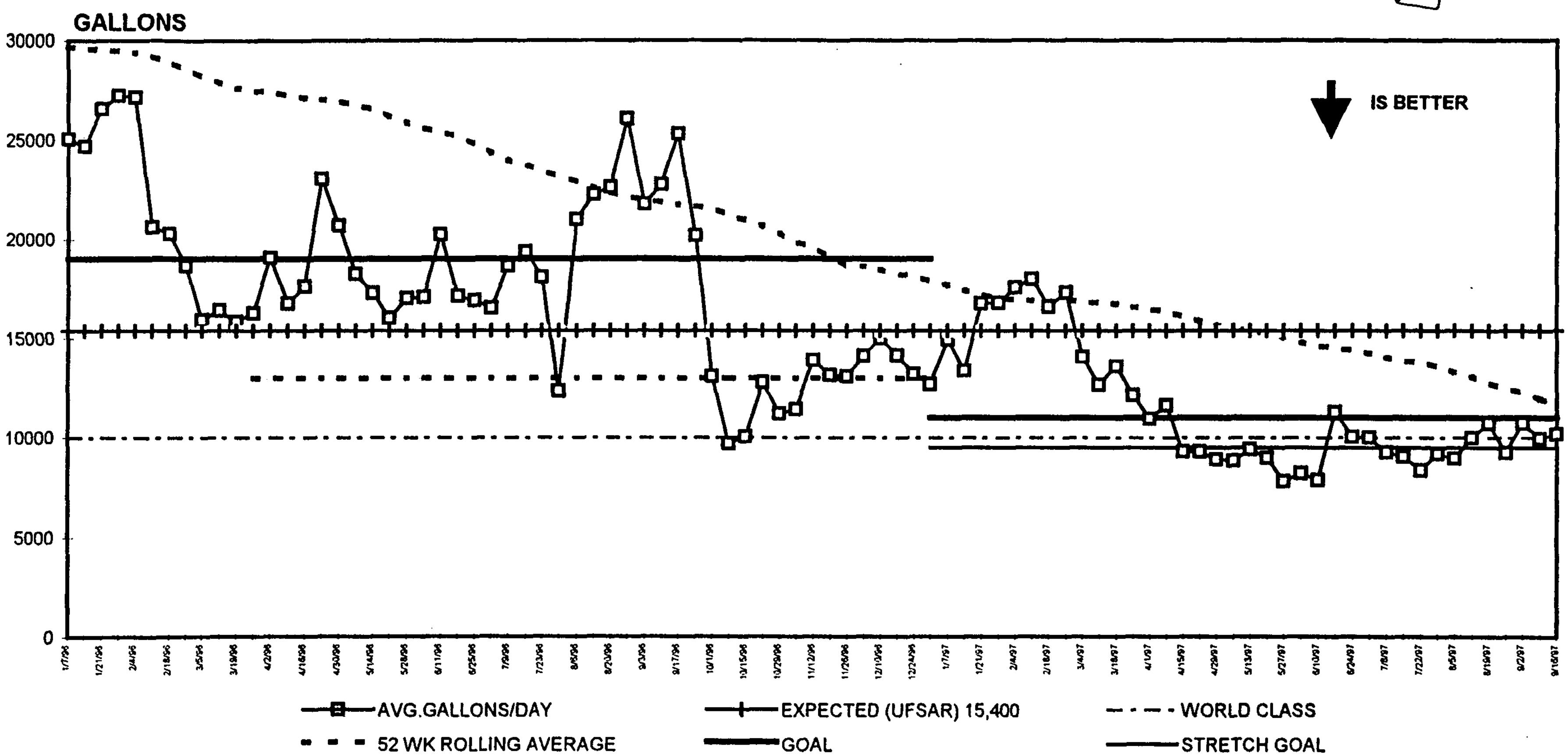
DEMINERALIZER EFFECTIVENESS

Demineralizer	DF	Notes
Floor Drain (Normal Stream)		
Floor Drain (Saltwater Stream)		
Equipment Drain		

PEACH BOTTOM ATOMIC POWER STATION

AVERAGE DAILY
FLOOR DRAIN COLLECTOR TANK INPUT

GOOD
JOB !!!

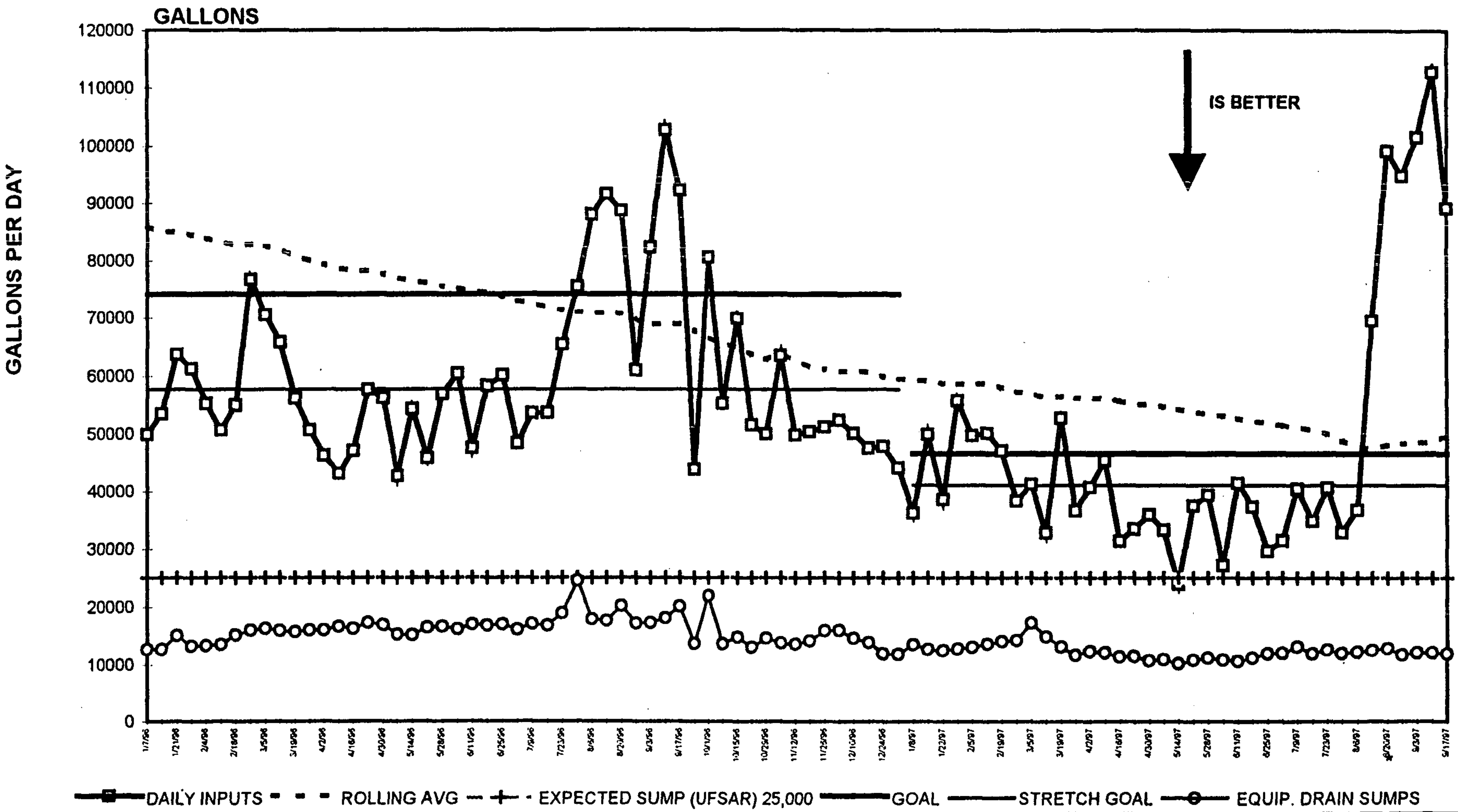


1997 GOAL IS < 11,000 GPD BY 12/31/97
STRETCH GOAL < 9,500 GPD BY 12/31/97

G	A0974188 - HV-3-08-53017 Leaking in U/2 Hold-up Pipe Tunnel	2R12
G	A1051603 - HV-3-01A-32044E Leaking through (Moisture Sep. Drn. Tk).	3R11

PEACH BOTTOM ATOMIC POWER STATION

EQUIPMENT DRAIN SYSTEM
Average Daily Inputs



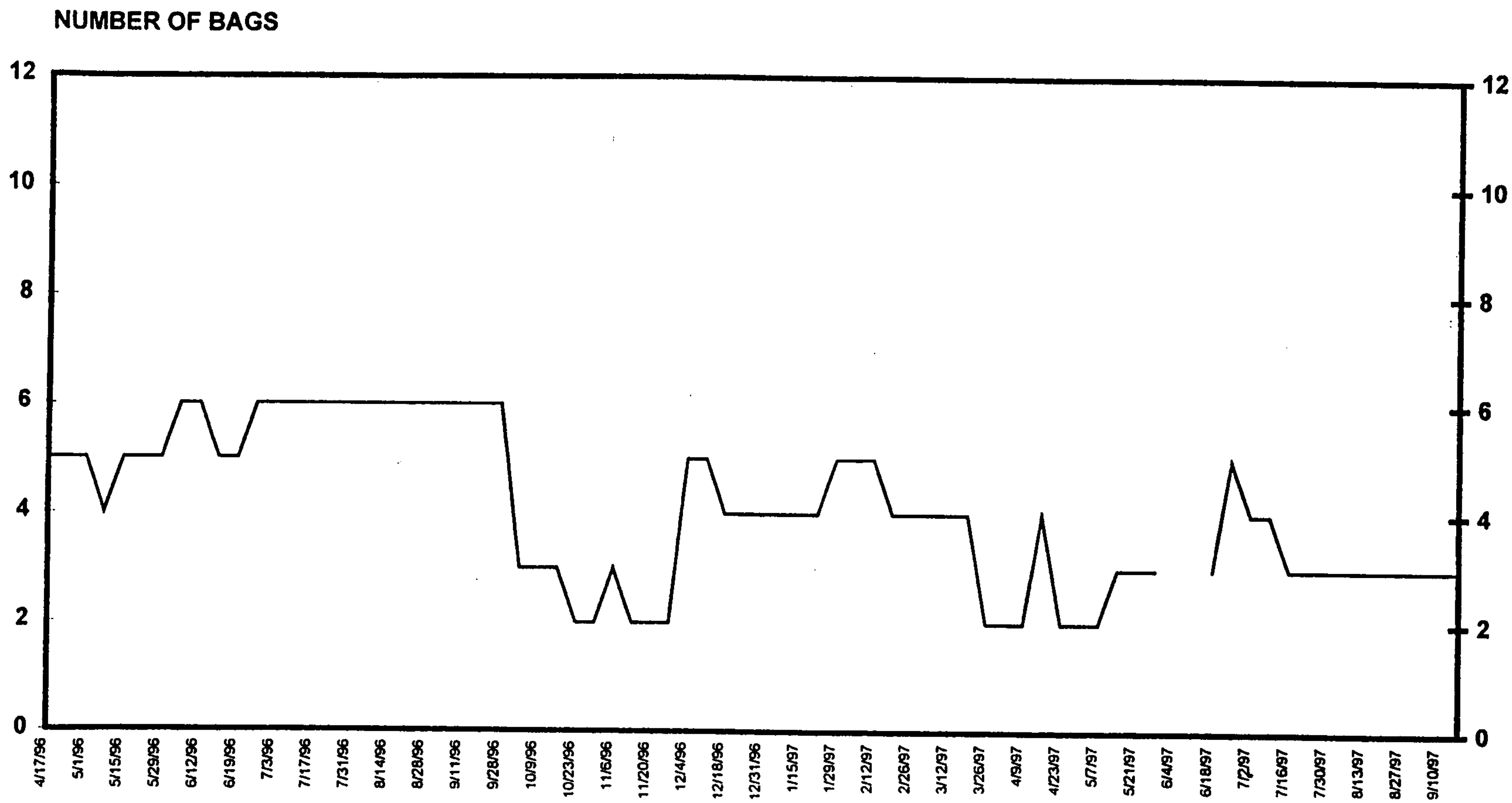
1997 GOAL IS 46,575 GPD BY 12/31/97
STRETCH GOAL IS 41,096 GPD BY 12/31/97

* Starting at this time frame reprocesses from Floor Drain System due to U/3 Torus Cleanup Project

U2 CBRT	Inleakage	700	Gal/Day
U3 CBRT	Inleakage	930	Gal/Day
	TOTAL	1,630	Gal/Day

PEACH BOTTOM ATOMIC POWER STATION
DRIP BAG CONTAINMENT

1996/1997



1 - FORCED OUTAGE
2 - REFUEL OUTAGE
0 - NON-OUTAGE

WEEKLY

—— TOTAL

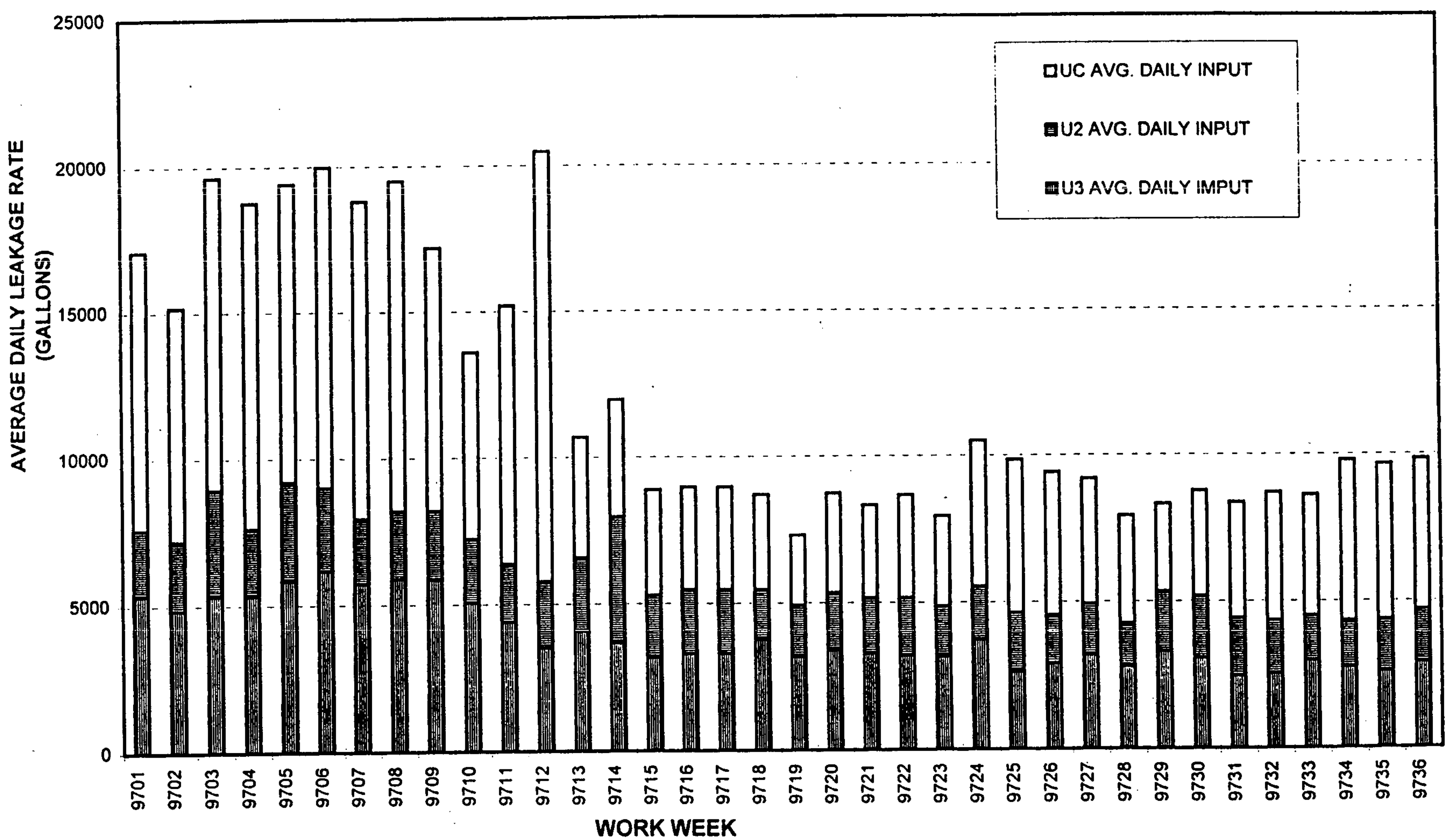
AGE

1 > 180 DAYS
1 - 90 - 180 DAYS
1 < 90 DAYS

DRIP.XLS

PEACH BOTTOM ATOMIC POWER STATION
PLANT LEAKAGE

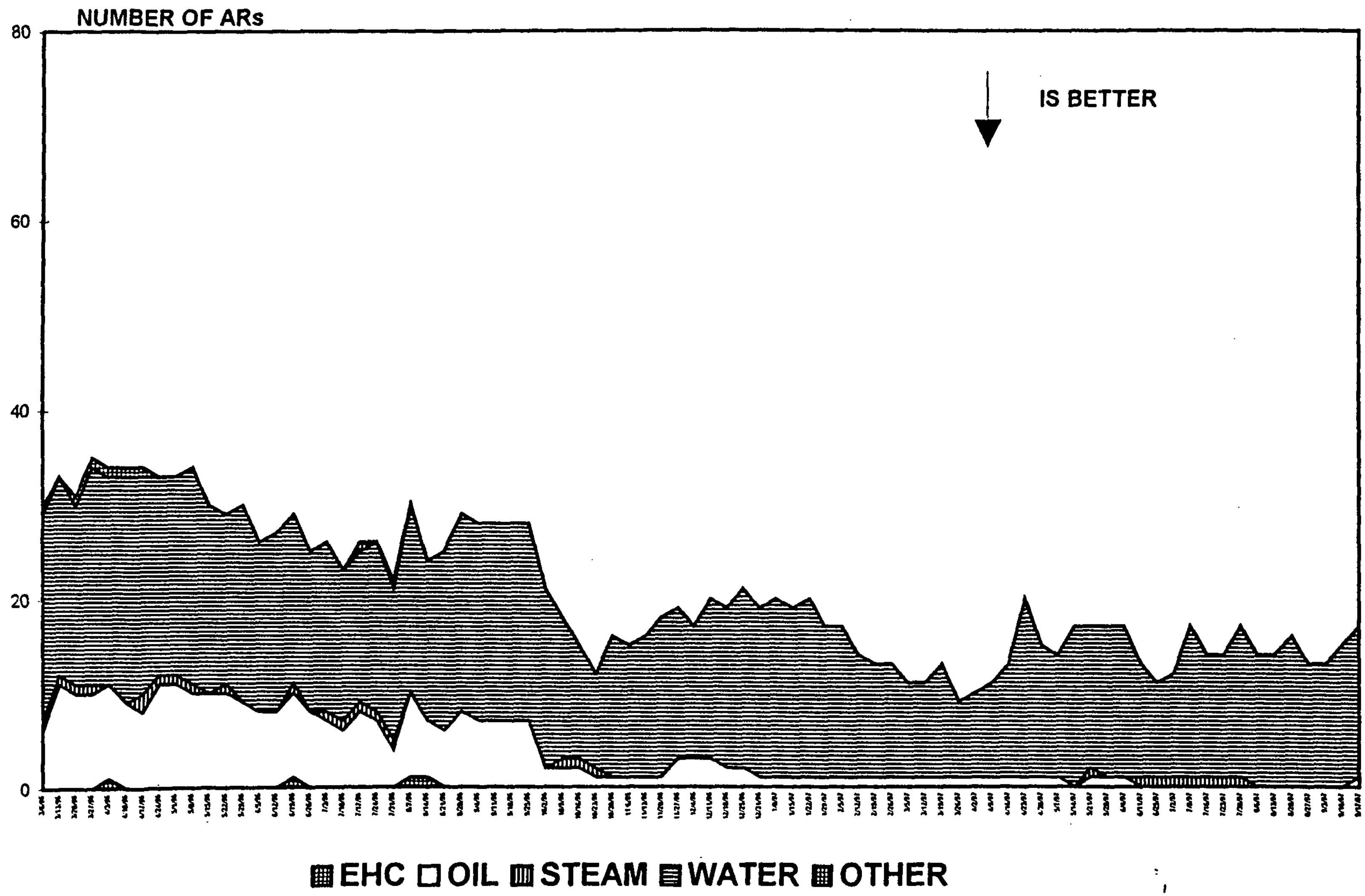
(Floor Drains and Equipment Drains)



PLTLEAK.XLS

SUMMARY OF LEAK TYPES IDENTIFIED
PEACH BOTTOM ATOMIC POWER STATION
NON OUTAGE

NOTE: This includes leaks inputting to radwaste identified by Action Request.



4 - FIN
11 - SCHEDULED
0 - RESCHEDULED
2 - NOT SCHEDULED

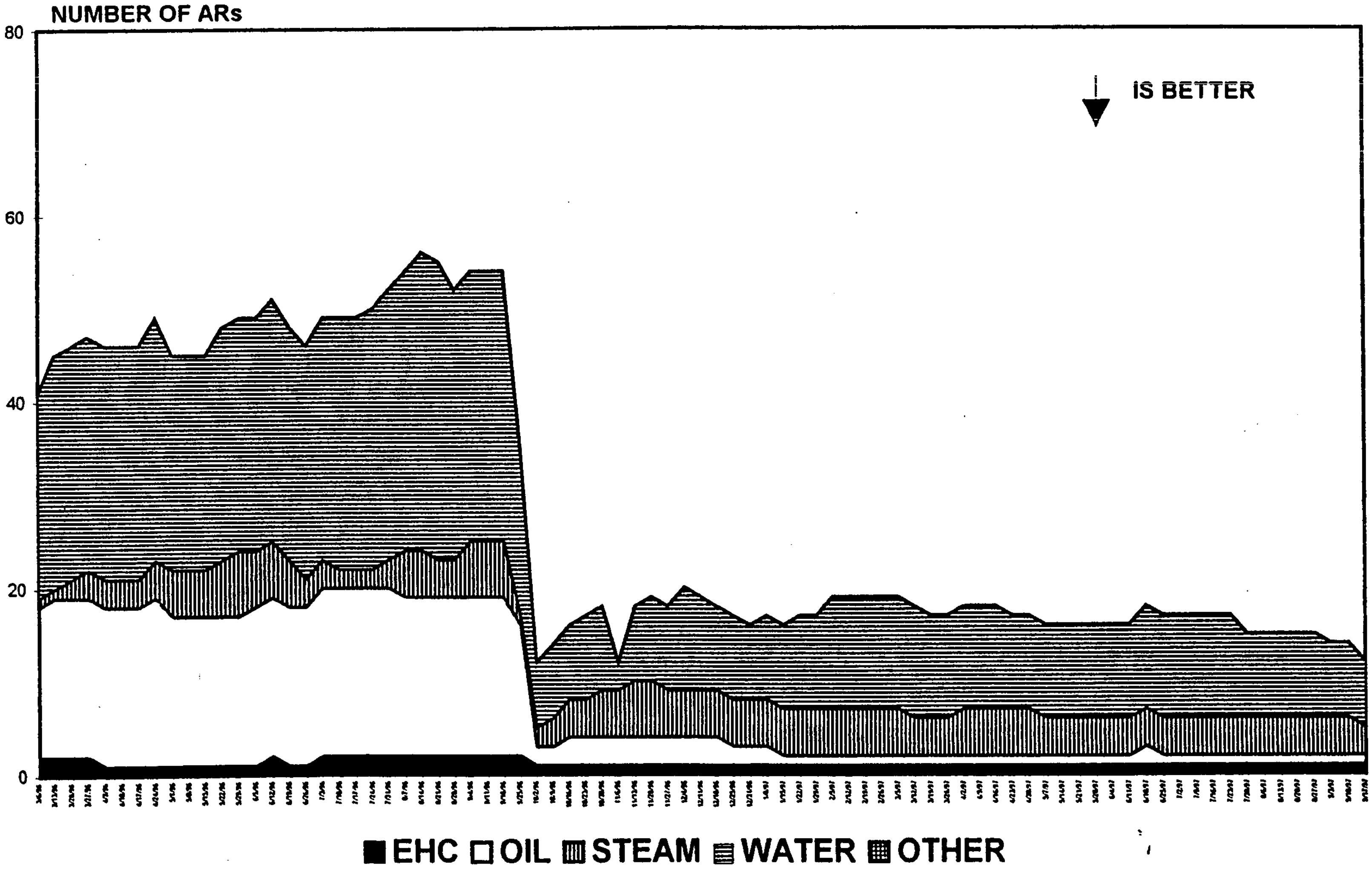
17 - TOTAL

GOAL
<10 by 12/31/97

SUMMARY OF LEAK TYPES IDENTIFIED
PEACH BOTTOM ATOMIC POWER STATION

OUTAGE/LOAD DROP

NOTE: This includes leaks inputting to radwaste identified by Action Request.

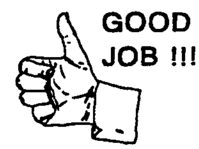


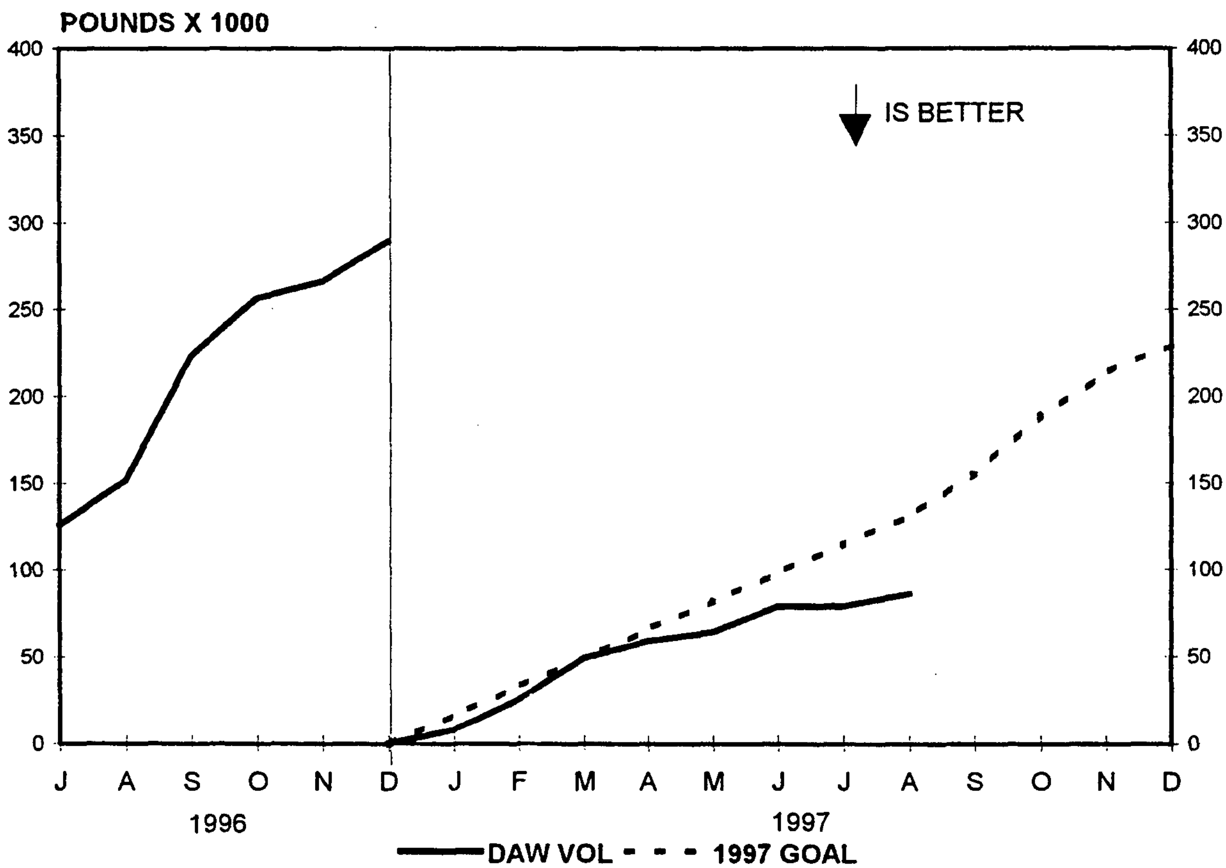
5 - 2F05
2 - 2R12
5 - 3R11

12 - TOTAL

UNPROCESSED RADWASTE GENERATED - PBAPS 2 & 3

The Unprocessed Radwaste Generated Performance Indicator is defined as the weight (in pounds) of Dry Active Waste (DAW), including Green Is Clean (GIC) rejected, that has been generated prior to shipment to a processor for volume reduction (incineration, super-compaction, metal-melt, etc.).



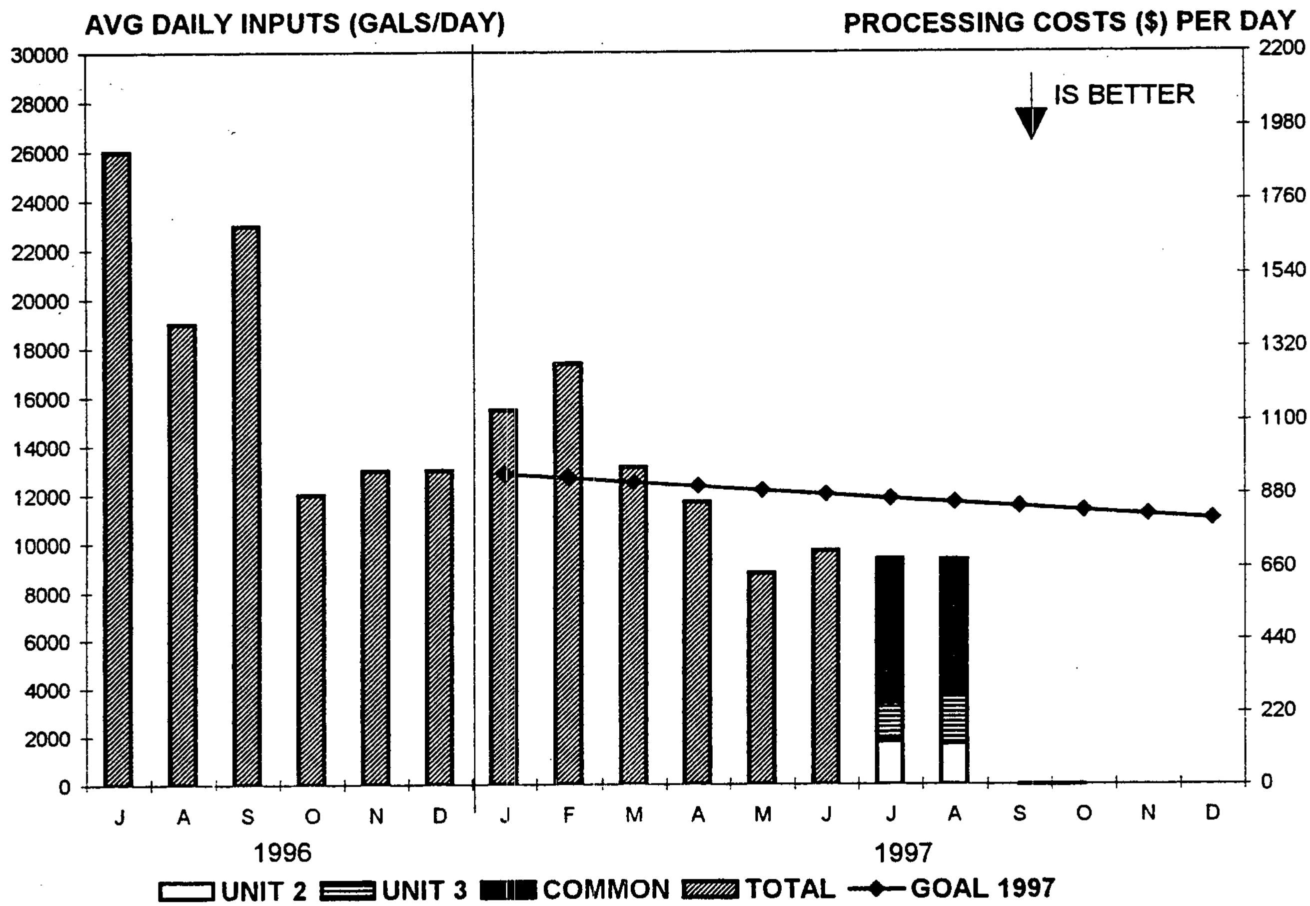


Analysis:

The weight of unprocessed DAW generated in August was 7,396 lbs. The year-to-date total is 86,439 lbs. Sorting and release of clean material found in <2 mR/hr DAW was continued in August.

FLOOR DRAIN SUMP INPUTS
PBAPS 2, 3 & COMMON

This graph displays the average daily water volume collected in the Floor Drain Sumps, and pumped to the Radwaste Floor Drain Collector Tank for processing. Processing Cost is based on 11 cents per gallon.



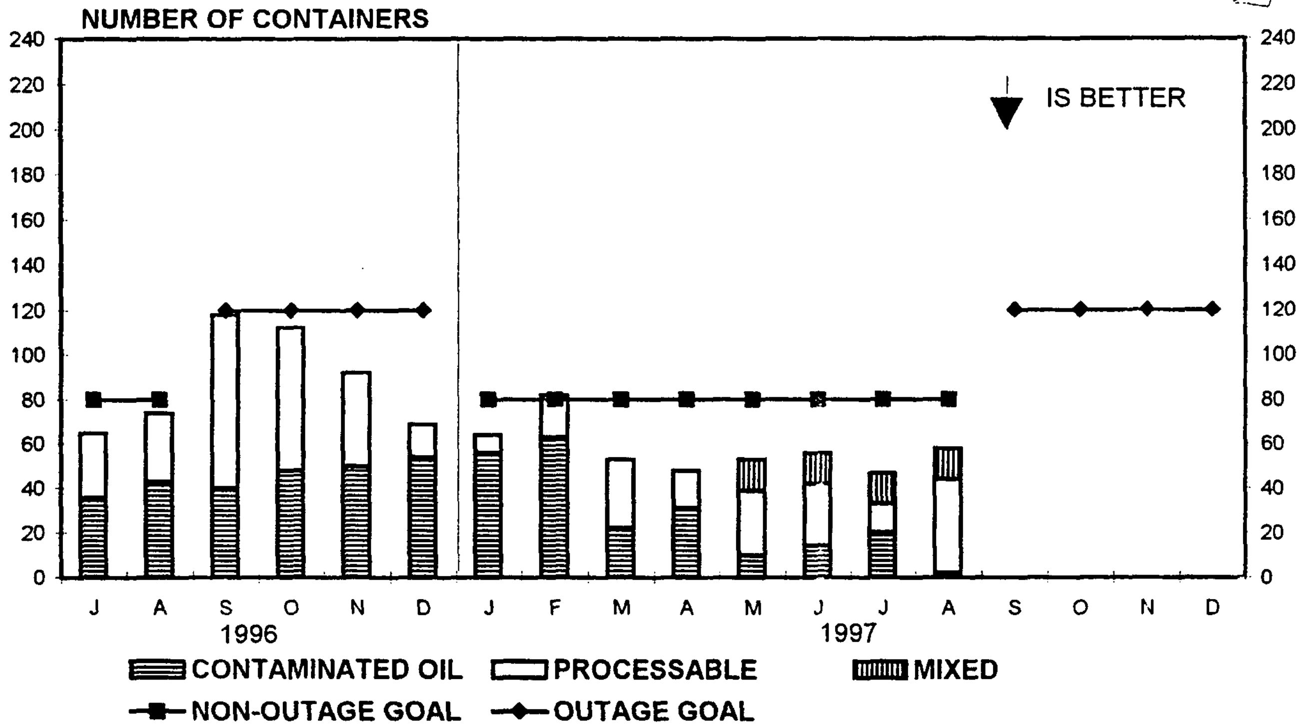
SIGNIFICANT INPUTS:	Amount	Schedule
A0974188	> 1/2 GPM	2R12
A1051603	> 1/2 GPM	3R11

Analysis:

The average daily Floor Drain System input for August was 9,332 gals/day. This value is down slightly from the 9,360 gals/day in July.

UNPROCESSED RADWASTE INVENTORY - PBAPS 2 & 3

The Unprocessed Radwaste Inventory Performance Indicator is defined as the total number of drums and boxes that contain any volume of Processable Liquids and Solids, Contaminated Oil, and Mixed Wastes. Processable Liquids and Solids are wastes that are routinely processed or treated by accepted techniques. Processable Liquids and Solids include drums of service water, oily water, SBL, mop water, and EPICOR charcoal. Oil wastes include contaminated lube oil and EHC fluid. Lube oil is incinerated on-site in the Auxiliary Boilers. EHC fluid is shipped to an off-site processor for incineration. Mixed Waste is radioactive waste that is also defined as a hazardous material and can only be processed under current federal or state regulations to a facility licensed under both NRC and EPA regulations. Mixed Waste currently includes containers of contaminated lead, paints, solvents, and freon.



Analysis:

The overall inventory of unprocessed radwaste increased from 48 to 58 in August. A total of 51 drums were processed, released as clean, transferred for incineration, or shipped off-site for processing.

Currently, 2 drums of contaminated lube oil remain on site. During August 11 drums of lube oil were transferred to Waste Oil Storage Tank, 5 drums of EHC fluid were shipped to SEG for incineration, and 2 drums of lube oil were released as clean.

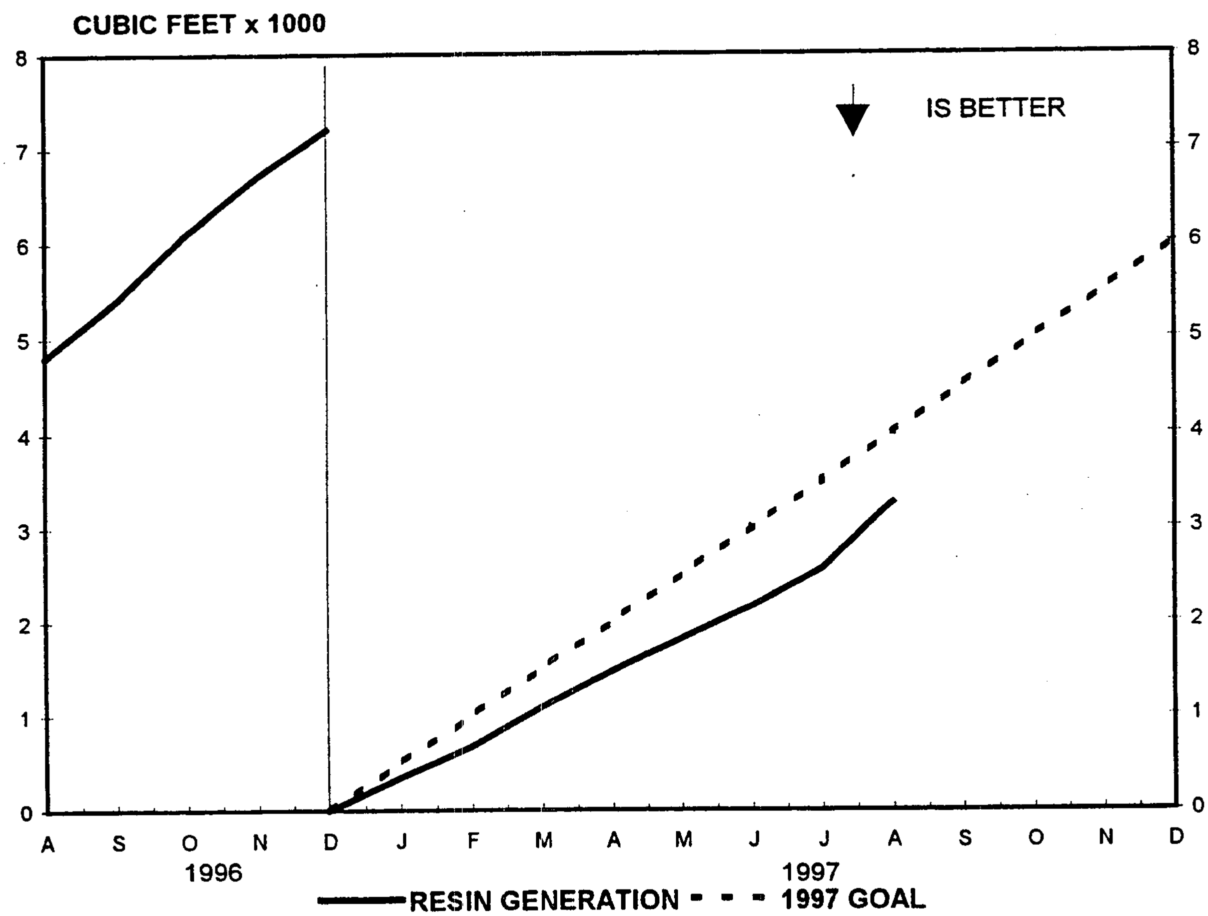
There are 42 drums of processable liquids (17 drums of mop water and 25 drums of service water) in inventory. During August 32 drums were processed.

There are 14 drums of mixed waste currently on-site. 1 drum of hard-to-process (grease) was shipped to SEG during August.

RESIN GENERATION
PBAPS 2 & 3

The Resin Generation Performance indicator is defined as the total amount of resin used in the Condensate and RWCU filter demins for both Units, the filter demins and deepbed demins for the Equipment and Floor Drain Collection Systems in Radwaste and the Fuel Pool Filter Demins. The indicated volume is prior to any volume reduction.

GOOD JOB !!!



Analysis:

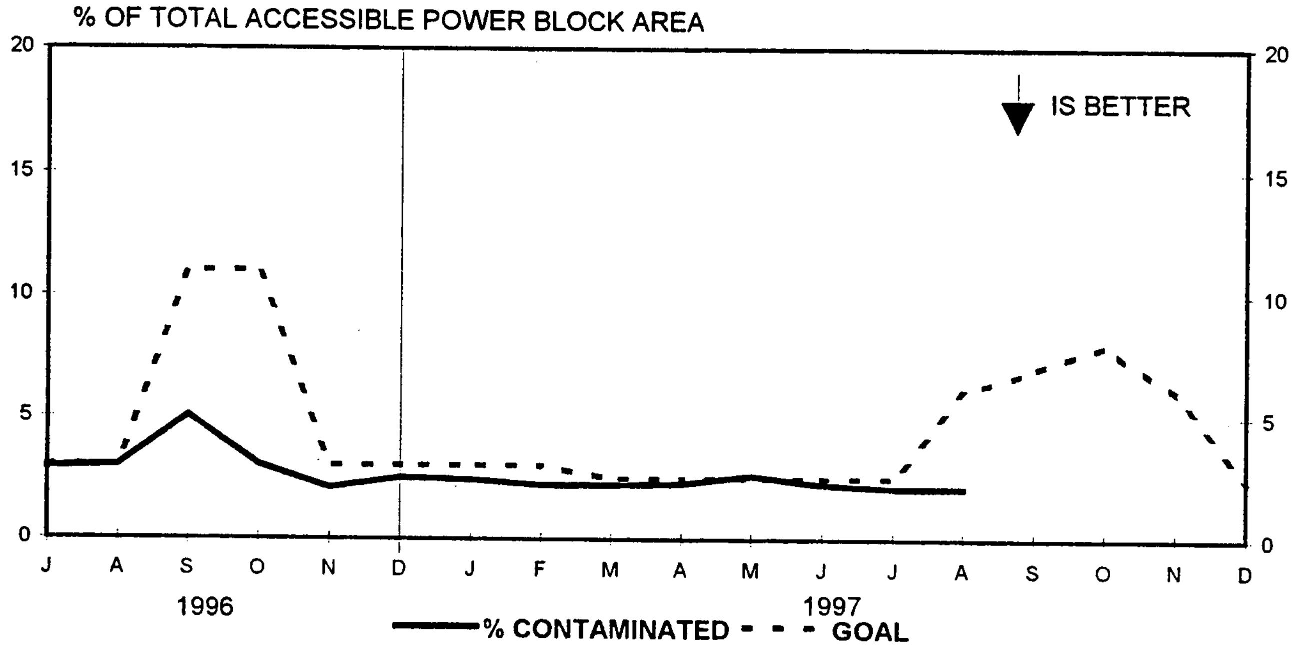
Resin usage for the month of August was 713 cu. ft. bringing the total for the year to 3,266 cu. ft. Lower generation rates in 1997 are resulting from the min-precoatable filters installed on the Condensate Filter Demins, decreased inputs to Radwaste and other system improvements. This months generation increased due to floor and waste deep bed regens and increased back washes due to the Torus Water Cleanup Project. Note that the waste deep bed was regenerated after a 350 day run. The year to date volume is 18% less than the goal and 32% less than last year.

SURFACE CONTAMINATION PERFORMANCE
PBAPS 2, 3, AND COMMON

The Surface Contamination Performance Indicator is defined as the percent of the plant that is contaminated. Areas are those with a count greater than 1000 DPM/100 CM^2. The total contaminated floor space is the summation of accessible contaminated areas as of the last day of the month. Inaccessible areas are areas like the drywell and condenser areas which are restrained from decon due to plant operating conditions.

Status Goal: 2.5% (Max.) 13,620 sq. ft. Accessible Area (Non-outage)
8.0% (Max.) 43,586 sq. ft. Accessible Area (Outage)

GOOD JOB !!!



Accessible Area % Contaminated =	Contaminated Accessible Area = Total Area	$\frac{11,428\ FT^2}{544,825\ FT^2}$	= 2.09%

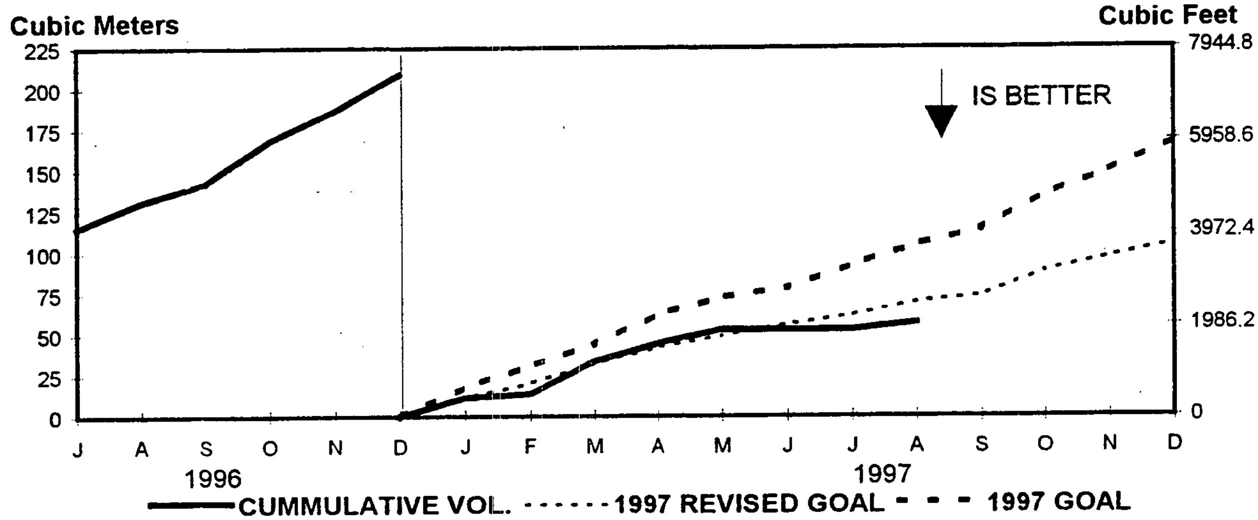
	Area Released/Area Decontaminated	Area Level Reduced	Contaminated	Change
Progress (FT^2)	0 /1,320	793	1,336	+ 16

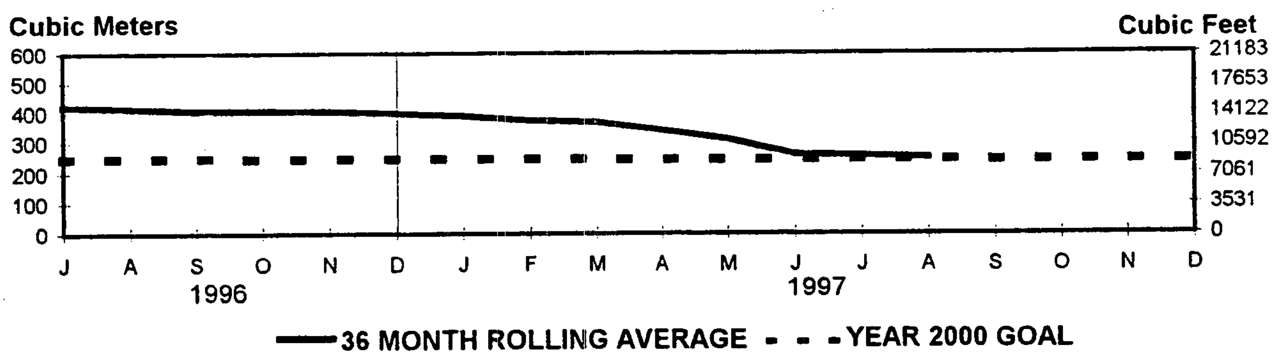
Analysis:

The contaminated area of the plant is 2.09%. The contaminated area of Unit 2 and Common is 1.44%. The contaminated area of Unit 3 is 2.90%. The contaminated areas of Unit 2 remained the same. 1000 sq. ft. of the U2 torus was recovered following a funnel drain overflowing onto the floor. The contaminated area of U3 increased slightly due to work area created at the torus hatch. The CRD flush cage was deconned to reduce levels.

VOLUME OF LOW-LEVEL SOLID WASTE PRODUCED - PBAPS

This indicator is defined as the volume of low-level solid radioactive waste (LLSRW) produced, in final form ready for burial, during a given period. The volume of radioactive waste that is not yet in final form ready for shipment is not included. The indicator is calculated using the amount of waste actually shipped for disposal, plus the change in inventory of waste in on-site storage in final form ready for burial. Low-level refers to all radioactive waste that is not spent fuel or by-product of spent fuel processing. The year 2000 INPO BWR goal is 125 cubic meters per unit (three year rolling average).





Analysis:

The goal for 1997 has been revised downward from 167 cubic meters to 105 cubic meters. The original goal was based on a 20 % reduction of the total generated in 1996. The revised goal now also accounts for volume reduction associated with use of the Quantum Catalytic Extraction Process (QCEP), utilized by MMT, Inc., for PBAPS condensate resin. Cumulative volumes for previous months have been adjusted to account for the use of QCEP.

During August, 4.1 cubic meters (3.9 cubic meters RWCU resin and 0.2 cubic meters DAW) of LLSRW were produced. The total for 1997 is 57.4 cubic meters which is 12.7 cubic meters (18.1%) below the August 1997 revised goal of 70.1 cubic meters.

.SWT

APRIL 1993

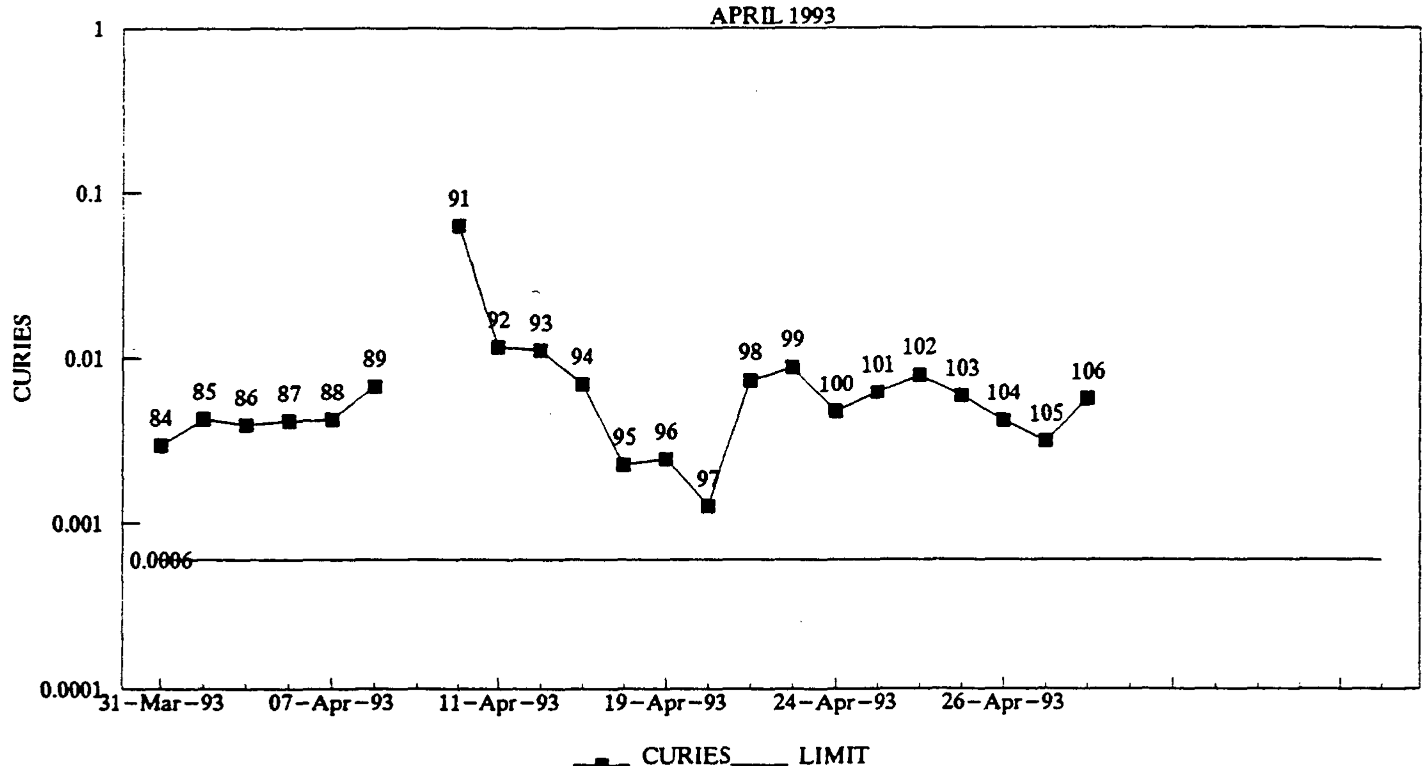
RELEASE TANK CURIE CONCENTRATIONS

(NOT INCLUDING NOBLE GASES AND TRITIUM)

DATE RELEASED	RELEASE TANK#	TANK I.D.	GALLONS RELEASED	CONCENTRATION uCi/ml (DECIMAL)	CONCENTRATION uCi/ml(SCI)	TOTAL ACTIVITY uCi (DECIMAL)	TOTAL ACTIVITY CURIES
31-Mar-93	84	1	25920	0.00003006	3.0078E-05	2947.00	0.002947
03-Apr-93	85	26	25960	0.00004365	4.3647E-05	4283.00	0.004283
06-Apr-93	86	1	25920	0.00004028	4.0285E-05	3947.00	0.003947
06-Apr-93	87	26	25160	0.00004376	4.3762E-05	4162.00	0.004162
07-Apr-93	88	1	25470	0.00004406	4.4061E-05	4242.00	0.004242
08-Apr-93	89	26	15820	0.00011186	1.1186E-04	6689.00	0.006689
CANCELLED				ERR	ERR	CANCELLED	0.000000
10-Apr-93	91	1	26977	0.00061605	6.1605E-04	62820.00	0.062820
11-Apr-93	92	26	11160	0.00027474	2.7474E-04	11590.00	0.011590
14-Apr-93	93	1	27240	0.00010819	1.0819E-04	11140.00	0.011140
15-Apr-93	94	26	25590	0.00007208	7.2077E-05	6972.00	0.006972
16-Apr-93	95	26	26670	0.00002233	2.2329E-05	2251.00	0.002251
19-Apr-93	96	1	26410	0.00002444	2.4442E-05	2440.00	0.002440
20-Apr-93	97	26	24580	0.00001357	1.3572E-05	1261.00	0.001261
22-Apr-93	98	1	26360	0.00007386	7.3855E-05	7359.00	0.007359
22-Apr-93	99	26	22480	0.00010365	1.0365E-04	8806.00	0.008808
24-Apr-93	100	1	28140	0.00023136	4.4543E-05	4738.00	0.004738
24-Apr-93	101	26	19290	0.00008558	8.5064E-05	6204.00	0.006204
25-Apr-93	102	1	23530	0.00008906	8.9057E-05	7921.00	0.007921
26-Apr-93	103	26	22520	0.00006923	6.9227E-05	5893.00	0.005893
26-Apr-93	104	1	22510	0.00004913	4.9126E-05	4160.00	0.004160
27-Apr-93	105	26	27190	0.00003061	3.0610E-05	3146.00	0.003146
28-Apr-93	106	1	26160	0.00005705	5.7046E-05	5641.00	0.005641

	2165440			137287.9	0.1372879	
TOTALS APR93	531057			178634	0.178634	0.178634 Ci
YEAR TO DATE TOTALS	2696497				0.3159219	

RELEASE TANK CURIES

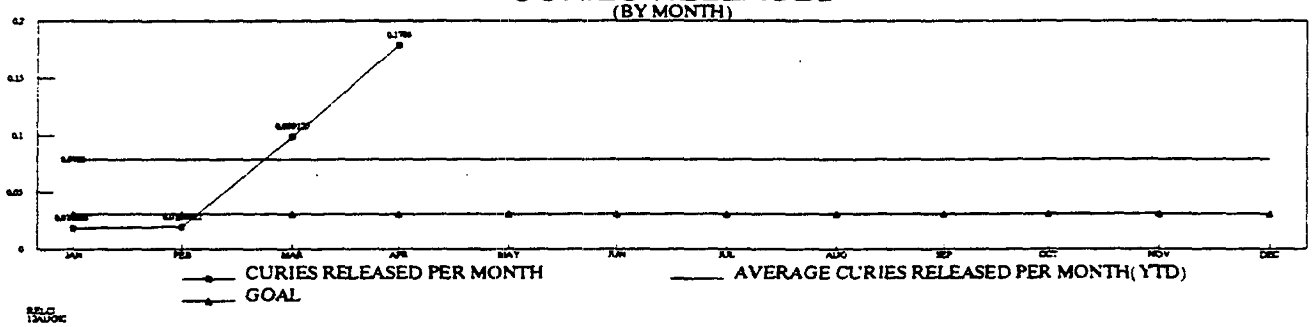


28apr93
RELAPR

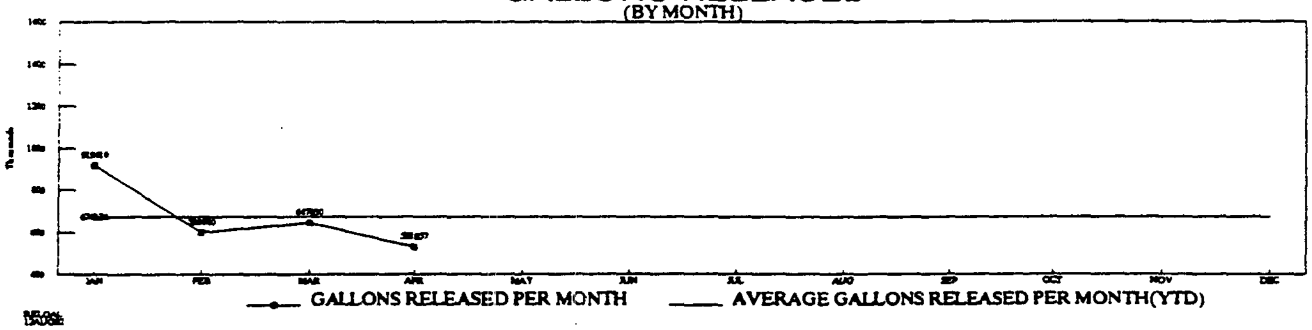
LIQUID RELEASE PERFORMANCE AVERAGES 1993

RELEASE MONTH	# TANKS RELEASED	GALLONS RELEASED	CURIES RELEASED	CURIE GOAL	OVER/ UNDER	PROJECTED TOTALS FOR 1993
JAN	36	919410	0.0186807	0.030833	−0.0121523	TOTAL GALLONS
FEB	24	599000	0.0194822	0.030833	−0.0113508	8089491
MAR	26	647030	0.099125	0.030833	0.068292	TOTAL CURIES
APR	22	531057	0.1786	0.030833	0.147767	0.9477
MAY				0.030833	−0.030833	
JUN				0.030833	−0.030833	
JUL				0.030833	−0.030833	
AUG				0.030833	−0.030833	
SEP				0.030833	−0.030833	
OCT				0.030833	−0.030833	
NOV				0.030833	−0.030833	
DEC				0.030833	−0.030833	
MONTHLY AVERAGES						
HIGH	36	919410	0.1786			
LOW	22	531057	0.0187			OVER/UNDER GOAL
AVERAGE	27	674124	0.0790	0.37		156.13%
TOTALS	108	2696497	0.3158879			

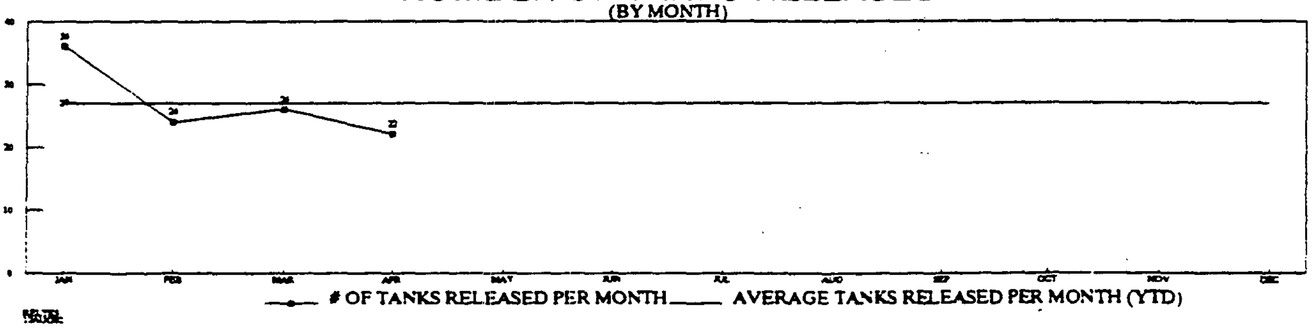
CURIES RELEASED
(BY MONTH)



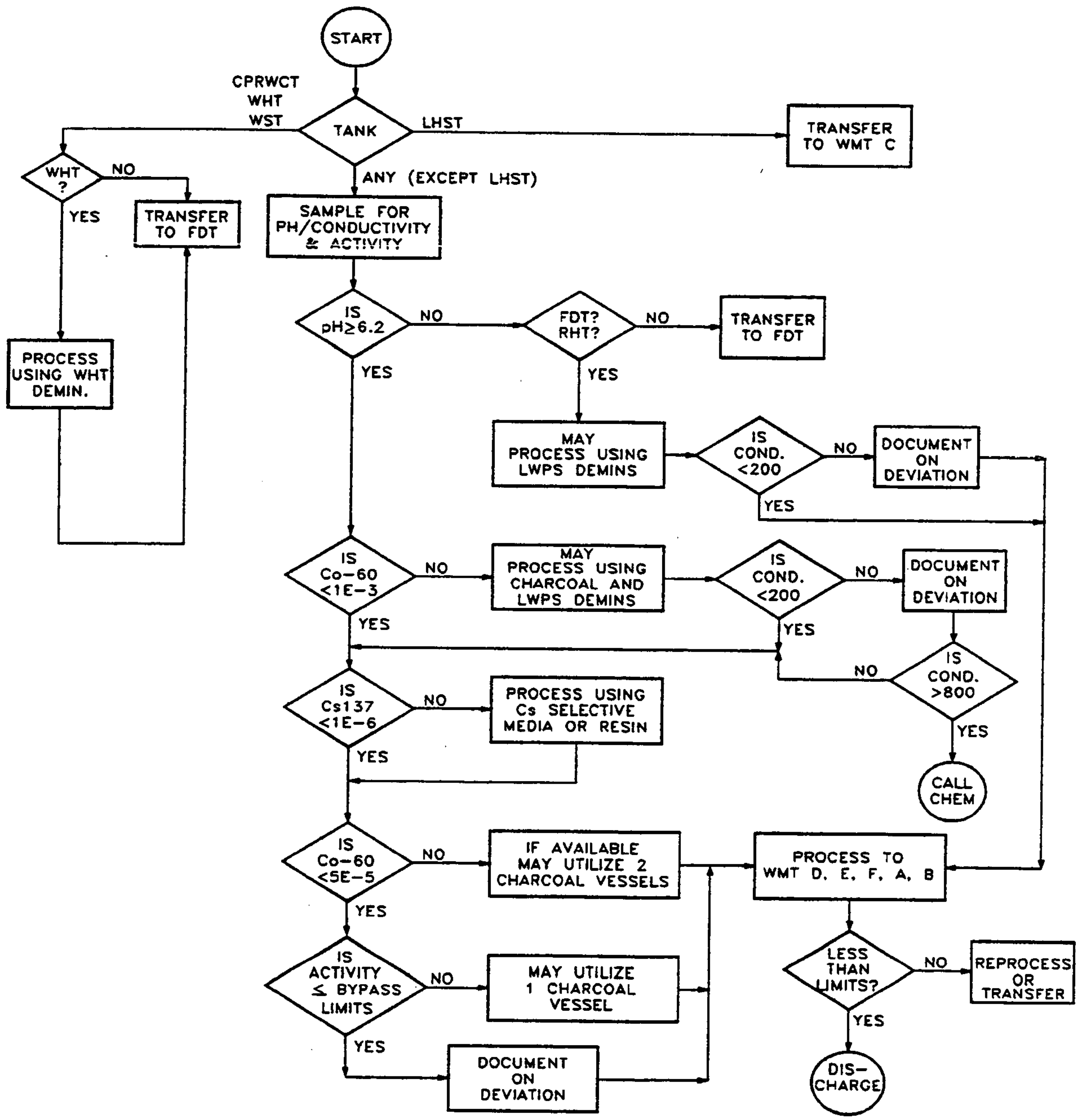
GALLONS RELEASED
(BY MONTH)



NUMBER OF TANKS RELEASED
(BY MONTH)



Appendix D – LRW Processing Logic Example


START
CPRWCT
WHT
WST
TANK
LHST
TRANSFER TO WMT C
WHT ?
NO
YES
TRANSFER TO FDT
ANY (EXCEPT LHST)
SAMPLE FOR PH/CONDUCTIVITY & ACTIVITY
PROCESS USING WHT DEMIN.
IS pH≥6.2
NO
YES
FDT? RHT?
NO
TRANSFER TO FDT
YES
MAY PROCESS USING LWPS DEMINS
IS COND. <200
NO
DOCUMENT ON DEVIATION
YES
IS Co-60 <1E-3
NO
MAY PROCESS USING CHARCOAL AND LWPS DEMINS
IS COND. <200
NO
DOCUMENT ON DEVIATION
YES
YES
NO
IS COND. >800
YES
CALL CHEM
IS Cs137 <1E-6
NO
PROCESS USING Cs SELECTIVE MEDIA OR RESIN
YES
IS Co-60 <5E-5
NO
IF AVAILABLE MAY UTILIZE 2 CHARCOAL VESSELS
PROCESS TO WMT D, E, F, A, B
YES
IS ACTIVITY ≤ BYPASS LIMITS
NO
MAY UTILIZE 1 CHARCOAL VESSEL
LESS THAN LIMITS?
NO
REPROCESS OR TRANSFER
YES
DOCUMENT ON DEVIATION
YES
DIS-CHARGE

AFL01040

Glossary of Abbreviations and Acronyms

10CFR61 – Code of Federal Regulations, Title 10, Part 61. Contains regulations related to waste characterization, classification and disposal.
ALARA – As Low As Reasonably Achievable. A concept to reduce personnel exposure to the lowest practical levels.
ANI – American Nuclear Insurers.
BWR – Boiling water reactor.
CCW – Component/closed cooling water.
CEP – Catalytic Extraction Process. A technology used for spent resin volume reduction.
CFD – Condensate filter demineralizer.
CST – Condensate storage tank.
Cu. Ft. – Cubic feet.
DAW – Dry active waste.
DF – Decontamination factor. Typically determined by comparing a LRW stream process or component's influent activity to effluent activity.
dP – Differential pressure/delta pressure.
F/D – Filter demineralizer.
FSAR – Final Safety Analysis Report.
HIC – High integrity container.
HVAC – Heating, ventilation & air conditioning.
INPO – Institute for Nuclear Power Operations.
LLD – Lower limit of detection.
LOCA – Loss of coolant accident.
LRW – Liquid radwaste. Typically floor drains in PWR stations and floor and equipment drains in BWR stations. In some PWRs, this waste stream would include reactor letdown waste.
NEI – Nuclear Energy Institute.
NRC - Nuclear Regulatory Commission.
O&M – Operations and Maintenance. The base budget for normal plant evolutions.
PM – Preventative maintenance.
PWR – Pressurized water reactor.
RCA – Radiologically controlled area.
RCS – Reactor coolant system.
RW – Radioactive waste.
RWCU – Reactor water cleanup. The primary reactor coolant purification system in BWR stations.
SFP – Spent fuel pool.
S/G – Steam generator.
SGBD – Steam generator blowdown. A system designed for removing impurities from the secondary side of PWR steam generators.
TRU – Transuranic.

URC – Ultrasonic resin cleaner. A system that employs ultrasonic waves and hydraulic separation to clean bead resin.

VR – Volume reduction. Typically calculated by comparing pre and post processing volumes in Cu. Ft.

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