

**Feasibility Study for the
Upgrade of the Process Waste
Treatment System**

**M. R. Peet
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**FEASIBILITY STUDY FOR THE UPGRADE OF THE
PROCESS WASTE TREATMENT SYSTEM**

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ACRONYMS

DCS	distributed control system
EIX	electrochemical ion exchange
GAC	granular-activated carbon
HEPA	high-efficiency particulate air
HVAC	heating, ventilation, and air conditioning
I&C	Instrumentation and Controls (Division)
LLLW	liquid low-level waste
LMER	Lockheed Martin Energy Research
LMES	Lockheed Martin Energy Systems
NPDES	National Pollutant Discharge Elimination System
ORNL	Oak Ridge National Laboratory
PW	process waste
PWTC	process waste treatment complex
SLLW	solid low-level waste
TDEC	Tennessee Department of Environment and Conservation
TTO	total toxic organic

1. INTRODUCTION

The following study presents the technical basis for combining the functions of the current Process Waste Treatment Complex—Building 3544 (PWTC-3544) with current operations at the Process Waste Treatment Complex—Building 3608 (PWTC-3608) at Oak Ridge National Laboratory (ORNL). Two of the current granular-activated carbon (GAC) columns at PWTC-3608 would be converted to zeolite columns, and PWTC-3608 would be operated such that the process waste stream would flow through the zeolite columns for removal of ^{137}Cs and ^{90}Sr after the process waste stream passes through a clarifier at PWTC-3608. This would modify the current operation: pumping process waste from the clarifier at PWTC-3608 to PWTC-3544 for the removal of radiological constituents using ion exchange. PWTC-3544 could then be taken out of operation, which is projected to generate significant cost savings.

2. BACKGROUND

During the last several years, ORNL has actively sought out areas in existing operations where improvements and cost savings could be made. One such area that was identified during reengineering of Waste Management is the treatment of process waste. Operational and technology improvements have been evaluated continuously. Considerable increased efficiency and cost savings would be realized by shutting down PWTC-3544 and completing the process waste treatment at either PWTC-3608 or a new facility. During the past five years, several alternatives and improvements have been identified and investigated, most intensely during the 1998 focused efforts of the Waste Management reengineering team.

One alternative investigated was the design and construction of a completely new process waste treatment facility that would be located adjacent to PWTC-3608. The new facility would increase the effective removal of radionuclides using zeolites and would eliminate the generation of liquid low-level waste (LLLW). A conceptual design report was prepared in January 1994 and was revised in March 1995. The estimated cost for this alternative was \$23M, the high cost of which prevented the project from receiving capital funding.

In 1996, an upgrade was completed on the process and nonradiological wastewater treatment system, which moved the process waste chemical precipitation (or softening) treatment step from the Process Waste Treatment Plant (now referred to as PWTC-3544) to the former Nonradiological Treatment Plant (now referred to as PWTC-3608). Since reconfiguration of the process waste treatment system, further work has been completed to identify treatment methodologies that would enable shutting down PWTC-3544. One of the methods investigated was use of an electrochemical ion-exchange (EIX) system to replace the ion-exchange columns at PWTC-3544. The EIX system would likely have been sited adjacent to Building 3608 and was estimated to cost \$6.3M for design and construction. Testing conducted by the Chemical Technology Division indicated that the EIX system would not perform satisfactorily without further development; thus, this alternative was removed from further consideration as a near-term option.

In addition to the alternatives that involve new facilities or significant additional facilities, two similar alternatives were developed to replace the GAC at PWTC-3608 with zeolites. These alternatives were determined to be low-cost, acceptable performance alternatives and are presented here. Zeolites have been used since the mid-80s in PWTC-3544 to supplement ion-exchange columns. In addition, the Chemical Technology Division has extensive laboratory and field experience using zeolites to remove radionuclides from process waste and other similar waste streams. This body of research and practical experience was the basis for the Waste Management reengineering decision to complete a feasibility study on the use of zeolites for radionuclide removal at PWTC-3608.

An additional option under consideration is to contract the treatment of process waste to a private company. This alternative could involve several options. The most likely alternative would be to contract with a private company to design, build, and operate an upgraded treatment system.

3. TECHNICAL DESCRIPTIONS AND DESIGN BASES FOR UPGRADE OPTIONS

Two viable options that were identified during preliminary investigations into methods to upgrade PWTC-3608 to provide radiological constituent removal met the basic requirements for treating process waste at the facility. Although both options include reconfiguring two of the existing GAC columns as zeolite columns, they differ in the point at which the process waste stream and the nonradiological waste stream are combined: Option I combined nonradiological and radiological wastewater at the first step in the process; Option II combined nonradiological and radiological wastewater immediately before radionuclide removal. The technical feasibility and the tradeoff between initial construction costs vs operating costs differ for each option. Therefore, the reengineering team decided to analyze each option separately. A technical description of each scenario and design option follows.

3.1 OPTION I: COMBINED WASTE STREAM FLOW THROUGH ZEOLITE COLUMNS

As mentioned previously, the difference between the two scenarios is mainly the degree of segregation of the two waste streams. In the first scenario, the process waste stream and the nonradiological waste stream would be combined early in the treatment process. In this scenario, the process waste would flow from the F-1006 clarifier and combine with the nonradiological waste stream at the filter feed tank (F-1008). From the filter feed tank, the combined waste stream would flow through the dual-media filters, the air stripper, the two zeolite columns, and the remaining GAC column. The flow path for Option I is shown in Fig. B.1 (Appendix B). This scenario has two primary advantages. One is the simplicity of construction and the resulting lower costs from use of existing equipment. The second advantage is the further reduction of ^{90}Sr being discharged to White Oak Creek. Currently, the nonradiological waste stream contains small amounts of ^{90}Sr at concentrations below the discharge limit that are not being removed. Option 1 would route this stream through the zeolite columns and remove the trace ^{90}Sr . A disadvantage of this scenario is that the zeolites would be expended at more than twice the rate that they would be if the waste streams were segregated. This increase would be caused by the flow of the entire treatment plant through the two zeolite columns. This option would also require that untreated radiological process waste be routed through the B-3608 air stripper, raising a concern about radionuclides being released to the air through aerosols from the air stripper exhaust.

3.1.1 Design Basis

This scenario would use mostly existing equipment. The majority of the new equipment needed would be for mixing the zeolites and transporting them into the former GAC columns. A description of the design elements follows.

3.1.1.1 Electrical Design

The electrical design elements would consist of power supply to the zeolite slurry agitator motor, two zeolite slurry pumps, a bag-unloading station, an exhaust fan, and two replacement GAC column feed pumps. Also included would be heat tracing for ~800 ft of piping.

3.1.1.2 Instrumentation Design

The GAC columns are controlled and operated via an existing distributed control system (DCS). The DCS enables operators to configure GAC column valves for different modes of operation via automated setup routines. The instrumentation design effort for Option 1 would consist primarily of changing existing DCS software to implement new valve setup routines, error checks, and backwash interlocks. Other tasks would include instrumentation and controls for the zeolite slurry mix tank as well as for new valves (see Appendix A for further details).

3.1.1.3 Structural Design

The structural design elements would consist of a concrete pad and anchor bolts for the slurry tank and an elevated steel platform for the slurry pumps and the bag-unloading station. The concrete pad would be 4 in. thick and 10 ft in diameter. The slurry pumps would need to be placed on a raised platform to keep the electrical systems out of the diked area in case of flooding.

3.1.1.4 Process Design

The process equipment needed to treat a combined process waste and nonradiological waste stream using zeolites as the ion-exchange media in the former GAC columns would include equipment for handling dry zeolites and a tank and mixer to suspend the zeolites in a slurry, which would be pumped to the former GAC columns (F-1019 and F-1020). In addition to the zeolite handling system, the distributors in the two former GAC columns would be replaced with distributors compatible for use with zeolites. A bulk bag-unloading station would be used to transfer the dry zeolites from the 50-ft³ bags used for transportation and storage into a slurry tank. The bulk bag-unloading station would sit on a platform above the slurry tank. The station would be equipped with a hoist and a mechanical agitator to assist in emptying the storage bags. The slurry tank would be a 3000-gal, cylindrical, flat-bottom carbon steel tank. The tank would include three baffles to ensure complete mixing and four 3-in. nozzles. The mixer would consist of a 2-hp motor, an 84-in. stainless steel shaft, and a 34-in. impeller.

3.1.1.5 Piping and Heating, Ventilation, and Air Conditioning (HVAC) Design

The piping required for the combined stream treatment system would consist of pumps and piping to transport the zeolite slurry to the former GAC columns, submersible pumps to feed the combined stream from the feed sump through the zeolite and GAC columns, and piping to carry the backwash from the zeolite columns to the diked area sump (see Figs. B.1, B.2, and B.3). From the diked area sump, existing pumps and piping would carry the backwash to the metals equalization tank (F-1001). The slurry pumps would be two 50-gal/min boundary layer viscous drag disc-type pumps. The piping from the slurry tank to the zeolite columns would consist of ~300 linear ft of 3-in.-diam, schedule-40 carbon steel welded pipe. The piping would be insulated with 1.5-in. elastomeric rubber and aluminum jacketing. The piping would run overhead and would require new pipe supports and pipe hangers. The process water supply to the slurry tank would be provided by a 3-in.-diam, schedule-40 carbon steel pipe, which would tee into the existing process water supply piping. The water supply piping would be insulated with 1.5-in. elastomeric rubber and aluminum jacketing.

The normal flow of the combined waste stream would empty from the air stripper into the existing GAC feed sump, as it is currently operated. Because of the expected higher pressure drop through the zeolite columns with the new nozzles, the existing GAC feed pumps would be replaced with two 760-gal/min submersible pumps. The other modification planned for the former GAC columns is the addition of overflow piping and vent modifications. The overflow piping would consist of 6-in., schedule-40 carbon steel welded pipe, which would run through the trench beneath the GAC columns, empty into the diked area sump, and serve as a header for the two zeolite columns. The new header would contain assorted tees, elbows, and pipe supports (see Fig. B.3).

The primary ventilation modifications for the new zeolite system would be to cover the existing spent carbon holding tank and construct a vented hood for the B-25 box-unloading area because the holding tank and unloading area would be used for spent zeolites in the new operating scenario (see Fig. B.4). Therefore, to control possible emissions of radionuclides from the spent zeolites, the holding tank would be covered with a 0.25-in.-thick carbon steel plate. For the B-25 box-unloading area, a Plexiglas canopy hood would be constructed. The hood would be vented through a bag-in/bag-out high-efficiency particulate air (HEPA) filter train using a 1000-ft³/min exhaust fan.

3.2 OPTION II: SEPARATION OF WASTE STREAMS

In the second scenario, the two waste streams would be kept separate up to the point at which the process waste is treated to remove radiological constituents. In this scenario, the process waste would flow from the F-1006 clarifier to the surge tank (F-1050), through two new filters, through the two zeolite columns, and to the filter feed tank (F-1008). At F-1008, the treated process waste would be combined with the nonradiological waste and would pass through the existing dual-media filters, the air stripper, and the single existing GAC column. The flow path for Option II is shown in Fig. B.2. The advantage of this scenario is the decreased use of zeolites because each zeolite column would treat only the process waste stream (350 gal/min maximum). The disadvantage of this scenario is the higher initial capital cost for the two new dual-media filters and the associated piping.

3.2.1 Design Basis

This scenario would require piping and associated pumps to transport the process waste stream from the existing surge tank (F-1050) through two new dual-media filters and on to the zeolite columns. The system to handle and load the zeolites into the former GAC columns, as required in the first scenario, would also be required for this scenario. A description of the design elements for Option II (which include elements from Option I) follows.

3.2.1.1 Electrical Design

The electrical design elements would consist of power supply to the zeolite slurry agitator motor, two zeolite slurry pumps, the bag-unloading station, and the exhaust fan. Also included would be heat tracing for ~1600 ft of piping. The electrical design elements for Option II would also include power supply for three new filter feed pumps.

3.2.1.2 Instrumentation Design

The existing GAC columns and filters are controlled and operated via an existing DCS. The DCS enables operators to configure GAC columns and filters for different modes of operation via automated setup routines. The instrumentation design effort for Option II would consist primarily of changes to the DCS to add new filter input/output and to implement new valve setup routines, error checks, and backwash interlocks. Other tasks would include implementing instrumentation for the zeolite slurry mix tank and the new filters (see Appendix A for further details).

3.2.1.3 Structural Design

The structural design elements would consist of a concrete pad and anchor bolts for the slurry tank and an elevated steel platform for the slurry pumps and the bag-unloading station. The concrete pad would be 4-in. thick and 10 ft in diameter. The slurry pumps would need to be placed on a raised platform to keep the electrical systems out of the diked area in case of flooding.

3.2.1.4 Process Design

The process equipment needed to treat a combined process waste and nonradiological waste stream using zeolites as the ion-exchange media in the former GAC columns would include equipment for handling dry zeolites and a tank and mixer to suspend the zeolites in a slurry that will be pumped to the former GAC columns (F-1019 and F-1020). In addition to the zeolite handling system, the distributors in the two former GAC columns would be replaced with distributors that are compatible for use with zeolites. A bulk bag-unloading station would be used to transfer the dry zeolites from the 50-ft³ bags used for transportation and storage into a slurry tank. The bulk bag-unloading station would sit on a platform above the slurry tank. The station would be equipped with a hoist and a mechanical agitator to assist in emptying the storage bags. The slurry tank would be a 3000-gal, cylindrical, flat-bottom carbon steel

tank. The tank would include three baffles to ensure complete mixing and four 3-in. nozzles. The mixer would consist of a 2-hp motor, an 84-in. stainless steel shaft, and a 34-in. impeller. Additional process design elements for Option II would consist of two 350-gal/min, dual-media filters with an air scour. An air compressor for the air scour would be included.

3.2.1.5 Piping and HVAC Design

The piping required for the separate stream treatment system would consist of pumps and piping to transport the zeolite slurry to the former GAC columns, filter feed pumps to feed the process waste stream from the existing surge tank (F-1050) through the dual-media filters and the zeolite columns, and piping to carry the backwash from the zeolite columns to the diked area sump. From the diked area sump, existing pumps and piping would carry the backwash to the metal equalization tank (F-1001). The slurry pumps would be two 50-gal/min boundary layer viscous drag disc type pumps. The piping from the slurry tank to the zeolite columns would consist of ~300 linear ft of 3-in.-diam, schedule-40 carbon steel welded pipe. The piping would be insulated with 1.5-in. elastomeric rubber and aluminum jacketing. The piping would run overhead and would require new pipe supports and pipe hangers. The process water supply to the slurry tank would be provided by a 3-in.-diam, schedule-40 carbon steel pipe, which would tee into the existing process water supply piping. The water supply piping would be insulated with 1.5-in. elastomeric rubber and aluminum jacketing (see Figs. B.1 and B.2).

Because of the high pressure drop through the dual-media filters and zeolite columns, the flow of the process waste stream from the existing surge tank (F-1050) through the dual-media filters and through the zeolite columns would be accomplished using three, 350-gal/min self-priming process pumps in place of the existing J-1050 pumps. There would also be 6-in.-diam piping and associated flanges, elbows, and valves (see Figs. B.5 through B.8). The other modification planned for the former GAC columns is the addition of overflow piping and vent modifications. The overflow piping would consist of 6-in., schedule-40 carbon steel welded pipe that would run through the trench beneath the GAC columns, empty into the diked area sump, and serve as a header for the two zeolite columns. The new header would contain assorted tees, elbows, and pipe supports (see Fig. B.3).

The primary ventilation modifications for the new zeolite system would be to cover the existing spent carbon holding tank and construct a vented hood for the B-25 box-unloading area because the holding tank and unloading area will be used for spent zeolites in the new operating scenario (see Fig. B.4). Therefore, to control possible emissions of radionuclides from the spent zeolites, the holding tank would be covered with a 0.25-in.-thick carbon steel plate. For the B-25 box-unloading area, a Plexiglas canopy hood would be constructed. The hood would be vented through a bag-in/bag-out HEPA filter train using a 1000-ft³/min exhaust fan.

4. OPERATIONS

The operating costs of the new zeolite system would primarily be the purchasing costs of zeolite and the disposal costs of the spent zeolite. In addition, there would be annual maintenance costs. We assume that the operators currently assigned to Building 3608 would be able to operate the zeolite column upgrade and thus that additional operator support would not be required. We also assume that additional supervisors and additional support from groups such as Health Physics and Industrial Hygiene would not be required.

For Option I, the estimate for zeolite usage is based on an average flow of process waste and nonradiological waste of 400 gal/min, a bed volume of 600 ft³, and exhaustion of the zeolites after 4000 bed volumes of throughput. Based on these values, the zeolite in the columns would be exhausted after 31 days. Therefore, the columns would require 12 changeouts per year, and 7200 ft³ of zeolites would be used per year.

For Option II, the estimate for zeolite usage is based on an average flow of process waste of only 175 gal/min, a bed volume of 600 ft³, and exhaustion of the zeolites after 4000 bed volumes of throughput. Based on these values, the zeolite in the columns would be exhausted after 71 days.

Therefore, the columns would require five changeouts per year, and 3000 ft³ of zeolites would be used per year.

The cost for disposing of the spent zeolites would also be a large operating cost. For Option I, 7200 ft³ of spent zeolites would be produced per year, as mentioned previously. Plans are to dry and dispose of the zeolites as a solid low-level waste (SLLW). For Option II, 3000 ft³ of zeolites would require disposal per year.

The solid waste volumes presented here are for the amount of spent zeolites generated. These solid waste volume estimates do not take into account that less solid waste would be generated in the clarifier as a result of operating the system at a near neutral pH rather than at a pH of 11.5, as is done currently (the zeolite treatment process does not require the removal of calcium and magnesium to the extent required by the current ion-exchange columns at PWTC-3544). *Although it would be possible to operate the clarifier at a near neutral pH, it might not be desirable to do so. Continuing to operate the clarifier at a high pH, as is done currently, would provide a safety factor in the event that an abnormally high slug of metals is introduced into the waste stream. If the clarifier were operated at a near neutral pH, dissolved metals would pass through the treatment system and be discharged at the effluent point. Therefore, any cost savings included should be weighed against the increase in operations risk.*

5. PERFORMANCE IMPROVEMENT

Upgrading PWTC-3608 will result in the performance improvements presented here. These improvements will result from eliminating the operation and routine maintenance of PWTC-3544 and its associated processes and by eliminating the generation of LLLW and SLLW at Building 3544. Elimination of treatment steps currently conducted in the process waste treatment plant would allow the facility to be shut down and turned over to the Surveillance and Maintenance Program for subsequent disposition.

Treating process waste for radiological constituents at PWTC-3608 would eliminate the need for operating and maintaining the current process waste treatment complex, PWTC-3544. The number of operators required by the Liquid and Gaseous Waste Operations Section could be reduced by four. The need for long runs of piping between PWTC-3608 and PWTC-3544 would be eliminated, along with the associated maintenance of this piping. Use of nitric acid to regenerate the ion-exchange resins would be eliminated. Therefore, the nitric acid evaporator would also no longer be needed.

As discussed previously, another improvement associated with the upgrade of Building 3608 would be the generation of less sludge at the clarifier. Currently, 4950 ft³/year of sludge is generated at the clarifier. When the process waste is routed through the zeolite columns, it will not be necessary to remove the calcium and magnesium from the incoming waste. We projected that only 200 ft³ of sludge would be generated per year. However, the clarifier could be operated at a pH of 11.5 to ensure that an unexpected slug of metals entering the process waste treatment system is treated. This conservative operational practice would continue to generate 4950 ft³ of sludge per year. In addition to the elimination of the majority of clarifier sludge generated, 100 ft³ of zeolites, which are currently used in a polishing step at PWTC-3544, would no longer be generated.

In addition to the items just mentioned, upgrading PWTC-3608 would eliminate generation of approximately 5100 gal/year of LLLW. This waste stream is currently produced when ion-exchange columns at PWTC-3544 are regenerated with nitric acid. This acid waste stream contains the strontium and cesium that had been absorbed on the PWTC-3544 ion-exchange resin. The nitric acid is neutralized with caustic, evaporated at PWTC-3544, and transferred to the ORNL LLLW evaporator feed tank. This highly concentrated LLLW represents ~30 wt % of the LLLW generated by ORNL per year. Approximately 1700 gal/year of water are required to flush out the transfer system after the waste is pumped to Melton Valley. This project would eliminate the production of 6800 gal/year of LLLW.

6. UNCERTAINTIES OF MODIFIED PROCESS

6.1 PROCESS UNCERTAINTIES

Although most of the uncertainties associated with the two options presented are process assumptions or issues that would be resolved during detailed design, there are several uncertainties that represent operational risks. These risks, potential consequences, probable solutions, and qualitative cost impact are summarized in Table 1.

Table 1. Increased but manageable operational risks

Risk	Potential consequences	Probable solutions	Cost impact
Existing column underdrain design may obstruct the complete removal of spent zeolite	High effluent ⁹⁰ Sr and ¹³⁷ Cs content	1. Replace underdrain system	Moderate/high
		2. Replace columns	High
Spent zeolite does not meet disposal criteria for retained liquid	Dewatering process must be improved	1. Modify/improve dewatering system	Low/moderate
		2. Subcontract dewatering process	Moderate
Unable to process wastewater during GAC changeout (one changeout since 1990)	Release of wastewater not treated through GAC	1. Perform changeout during low demand period. Allowable hold up is 1-3 days. Assume changeout occurs in about 8 hours	None
		2. Add second GAC column	High
Unable to process wastewater during zeolite changeout. Project assumes that single-column operation is adequate during zeolite changeout	High effluent ⁹⁰ Sr and ¹³⁷ Cs	1. Recycle wastewater until column changeout is complete	Low
		2. Add third zeolite column	High
Overall process is not as forgiving as current operation because of modified chemical precipitation	Greater potential for NPDES violations	1. Perform chemical precipitation (with associated sludge production)	Moderate/High

Additional operational uncertainties were considered. The feasibility study was based on the following resolution of these uncertainties.

- **Pressure drop through zeolite media and new nozzles vs pressure drop through existing GAC columns**—For Option 1, plans are to replace the current GAC feed pumps with larger pumps to handle the expected higher pressure drop through the columns when they are converted to zeolite columns. For Option 2, plans are to replace the existing pumps that currently transfer process waste from the surge tank (F-1050) to PWTC-3544 with larger pumps to handle the flow from F-1050 to the new dual-media filters and through the zeolite columns. These assumptions would be verified by calculations during detailed design.
- **Depletion rate of zeolite**—Calculations for the operating costs assume that for the combined flow, a 600-ft³ bed would be used and would be exhausted after 4000 bed volume throughputs. In this scenario, the zeolites would be changed every 31 days. For the process-waste-only stream, a 600-ft³ bed volume would also be used. Again, the zeolites would be exhausted after 4000 bed volume throughputs; thus, the zeolites would be changed out every 71 days.
- **Effluent concentration of ¹³⁷Cs and ⁹⁰Sr**—The Derived Concentration Guidelines for ¹³⁷Cs and ⁹⁰Sr are 111 Bq/L and 37 Bq/L, respectively.
- **Removing lag and backup GAC columns (only one GAC column would be available to treat the combined process waste nonradiological waste stream)**—Plant performance data indicate that operation of one GAC column would be adequate for maintaining the same effluent organic concentrations as is currently being obtained. We project that the concentration of mercury in the effluent would increase from about 50 parts per trillion to 100 parts per trillion. Alternative process options are being evaluated for maintaining or improving mercury removal with respect to current levels.
- **Running untreated process waste through the air stripper**—In Option I, the combined process waste and nonradiological waste stream would flow through the air stripper before the combined streams would flow through the zeolite columns. Therefore, radionuclides could become entrained in water droplets and escape from the air stripper. The amount of radionuclides that could escape has not yet been determined, nor has the potential risk associated with this event. If Option I is selected, this issue would be resolved before proceeding.
- **Shielding requirements for zeolite columns**—Initial shielding calculations indicate that shielding would not be required for the zeolite columns; therefore, the conceptual design and cost estimate do not include shielding. Further calculations would be performed during design to verify this.
- **DCS software modifications**—Significant modifications to existing DCS software would be required to implement either option. The DCS is an integral part of the process waste treatment system and cannot be taken out of service to support software development. Consequently, software development would have to be conducted on a small development system available from the Instrumentation and Controls (I&C) Division. This development system is not an exact duplicate of the process waste treatment system DCS system; therefore, the software cannot be tested completely. At some point, the new software would have to be installed on the DCS system and be tested in place. There is some risk that the software would not perform as required and would need further modification. One way to mitigate this risk would be to install and test the new software before the zeolite columns are converted. This would allow the old software to be reloaded if the new software does not perform as required.
- **Effective removal of zeolites during changeouts**—The underdrain and distributors in the current configuration in the GAC columns could cause difficulty in removing all of the spent zeolites during changeouts (see Figs. B.3 and B.4). Modifications to the existing GAC columns to facilitate zeolite removal, such as the installation of a view port and a sluicing wand, would be determined during detailed design.
- **Dewatering zeolites**—The existing GAC dewatering system could be inadequate for dewatering zeolites. This would need to be verified during design.

- **Excessive breakage of zeolites**—Design must take into consideration the fact that granular zeolites are fragile. Excessive breakage of zeolites could result in fines and potential operational difficulties.
- **Shutting down the clarifier**—We assume that the National Pollutant Discharge Elimination System (NPDES) limits for metal removal (such as copper) would be achieved without precipitation.
- **Concentration of ^{233}U** —Whether zeolites remove significant quantities of ^{233}U is unknown. The Chemical Technology Division would conduct tests to determine whether zeolites remove sufficient quantities of ^{233}U and whether precipitation (and at what pH) would be required.

6.2 REGULATORY UNCERTAINTIES

Interaction with regulators is an important part of this project because these facilities contribute to the site's NPDES-permitted outfall. Because of the changes in operation, approval from the Tennessee Department of Environment and Conservation (TDEC) would be required before construction. Factors that the TDEC should review include the following:

- If the pH of the clarifier is lowered, mercury in the effluent could increase and other metals could exceed discharge limits.
- Option 1 would include running untreated process waste through the air stripper, which could require a change to the air permit, as well as TDEC approval of the concept. However, this approach was not recommended.
- Concentration of total toxic organics (TTOs) in the treatment plant effluent could be affected by eliminating the backup GAC column. The TTO concentration of the influent is very low, and the daily maximum permit limit of 2.13 mg/L has not been exceeded. Essentially all TTO removal occurs in the first carbon column that will continue in operation.
- Oil and grease in the treatment plant effluent could be affected by eliminating the backup GAC column. The oil and grease daily maximum limit is 15 mg/L. Currently, oil and grease are detected in 10% of the effluent analysis. However, oil and grease have never exceeded limits (average analysis is 11 mg/L). Therefore, the proposed modified treatment system is expected to meet regulatory requirements.

7. CONCLUSIONS

The ORNL reengineering initiative actively evaluated existing operations for improvements and cost savings. One improvement identified during Waste Management reengineering was improvement of process waste treatment. Considerable increased efficiency and cost savings would be realized by shutting down PWTC-3544 and completing process waste treatment at PWTC-3608.

During this feasibility study, two options were analyzed for combining the functions of PWTC-3544 with operations at PWTC-3608. Two of the current GAC columns at PWTC-3608 would be converted to zeolite columns, and PWTC-3608 would be operated such that the process waste stream would flow through the zeolite columns for removal of ^{137}Cs and ^{90}Sr after the process waste stream passes through a clarifier at PWTC-3608. This modification of the current operation would allow PWTC-3544 to be taken out of operation.

Although both options include reconfiguring two of the existing GAC columns as zeolite columns, they differ in the point at which the process waste stream and the nonradiological waste stream are combined: Option I combined nonradiological and radiological wastewater at the first step in the process; Option II combined nonradiological and radiological wastewater immediately before radionuclide removal. Option II was selected as the preferred alternative based on significant reduction in SLLW generation, reduction in LLLW generation, and improved efficiency in the operating facilities. In addition, Option II does not involve an additional regulatory concern regarding the potential release of radionuclides at the air stripper. Operational factors must be considered if the process waste treatment

system is modified. For example, the modification could include an alternative method of mercury removal from wastewater—a process that would require development.

An additional option under consideration is to contract the treatment of process waste to a private company. The most likely alternative would be to contract with a private company to design, build, and operate an upgraded treatment system.

APPENDIX A

**INSTRUMENTATION AND CONTROL MODIFICATIONS
FOR THE PROCESS WASTE SYSTEM UPGRADE**

**APPENDIX A. INSTRUMENTATION AND CONTROL MODIFICATIONS
FOR THE PROCESS WASTE SYSTEM UPGRADE
(rev. 2/13/98)**

A.1 COLUMN OPERATING MODES

After the upgrade, the two zeolite columns (F-1020 and F-1019) will have the following possible configurations:

- Lead: Flow goes through the lead column first. Other column must be the lag column by default.
- Lag: Flow goes through the lag column second. Other column must be the lead column by default.
- Single: Flow goes through the column and then directly to GAC column F-1018.
- Standby: Column is taken off line. Column must be placed in standby before it can be backwashed.

(These configuration definitions mean roughly the same thing that they did before the upgrade. The main difference is that flow now goes to GAC column F-1018 rather than effluent tank F-1021).

For GAC column F-1018, the former lead/lag/single configurations must be redefined to a single “normal” configuration, giving the following possible configurations:

- Normal: Flow goes through the column.
- Standby: Column is taken off-line. Column must be placed in standby before it can be backwashed. Process Waste (PW) processing must be shut down or put in recycle before the column can be put into “standby.”

This leads to the following allowable combinations of column configurations:

F-1020 (zeolite)	F-1019 (zeolite)	F-1018 (GAC)	Comments
Lead	Lag	Normal	A normal operating mode
Lag	Lead	Normal	A normal operating mode
Single	Standby; Backwash	Normal	PW processing continues while F-1019 gets backwashed
Standby; Backwash	Single	Normal	PW processing continues while F-1020 gets backwashed
Single	Single	Normal	Zeolite columns in parallel. [PW processing continues; probably not a normal situation]
Standby; Backwash	Standby; Backwash	(Don't care)	PWTS shut down
(Don't care)	(Don't care)	Standby; Backwash	PWTS shut down

A.2 COLUMN VALVE CONFIGURATION CHANGES

With the new column configuration, several valves are no longer used and in fact should be replaced with blank flanges to prevent accidental contamination. In particular, the following valves should be removed and blanked off:

- FCV-611 and FCV-612. (Prior to upgrade, F-1018 could serve as the lead column and its discharge be routed to a lag column. These valves served to route the F-1018 discharge to the lag column. Since this configuration is no longer allowed, these valves should be disabled).
- FCV-637 and FCV-657. (Prior to upgrade, it was possible to run F-1019 and F-1020 in “single” mode with their discharges going straight to holding tank F-1021. This configuration is no longer allowed, so these valves should be disabled).

A.3 COLUMN SOFTWARE MODIFICATIONS

Operation of the three existing GAC columns is automated. Operators select an operating mode, and valves are reconfigured automatically on the basis of that selection. The software required to accomplish this automation is quite complicated, and it will take a significant effort to modify it. Software changes required include:

- Revise automatic column valve setup to implement new valve configurations.
- Revise the error checking that looks at the configurations the operator has selected and either allows or disallows the configuration changes.
- Revise operator display graphics.

Given the complexity of the software and the inability of Operations to sustain long periods of down time, the software modifications must be tested off-line. The I&C maintenance staff has a development system that can be used to perform off-line testing. Loading and on-line testing of the software will have to be coordinated with Operations. It may be possible to load and test the software before the actual conversion to zeolite takes place. This would mitigate some of the risk inherent in the startup of the new software. If significant problems were encountered, the old software could be reloaded and the plant restarted.

No training for software development was included in the cost estimate. A number of Lockheed Martin Energy Research (LMER) and Lockheed Martin Energy Systems (LMES) employees are capable of performing the work.

Current plans for software implementation are as follows:

- LMER to take responsibility for Functional System Design document and Bailey PCU program modifications. (LMES has persons with training and experience to do this work and so could also be given a subcontract to handle it). This includes both coding and off-line testing of the PCU program modifications. Off-line testing can be performed on a development system in possession of the I&C Division.
- I&C Division to handle modifications to Bailey DCS operator interface graphics.
- On-line testing to be performed jointly with LMER, I&C, Operations, and possibly LMES.

A.4 ZEOLITE SLURRY TANK OPERATIONS

Since zeolite slurry mix and transfer operations will take place at the tank, interface requirements with the Bailey DCS are very limited. The only interface included is a high-tank-level alarm to the DCS. All mix and transfer operations will be conducted via pushbuttons on an instrument enclosure at the tank.

Two automated functions are planned. First, a pushbutton is provided to initiate filling the tank to a predetermined level. Second, a pushbutton is provided to initiate pumping slurry from the tank until the level goes below a predetermined level.

APPENDIX B

PIPING SCHEMATICS

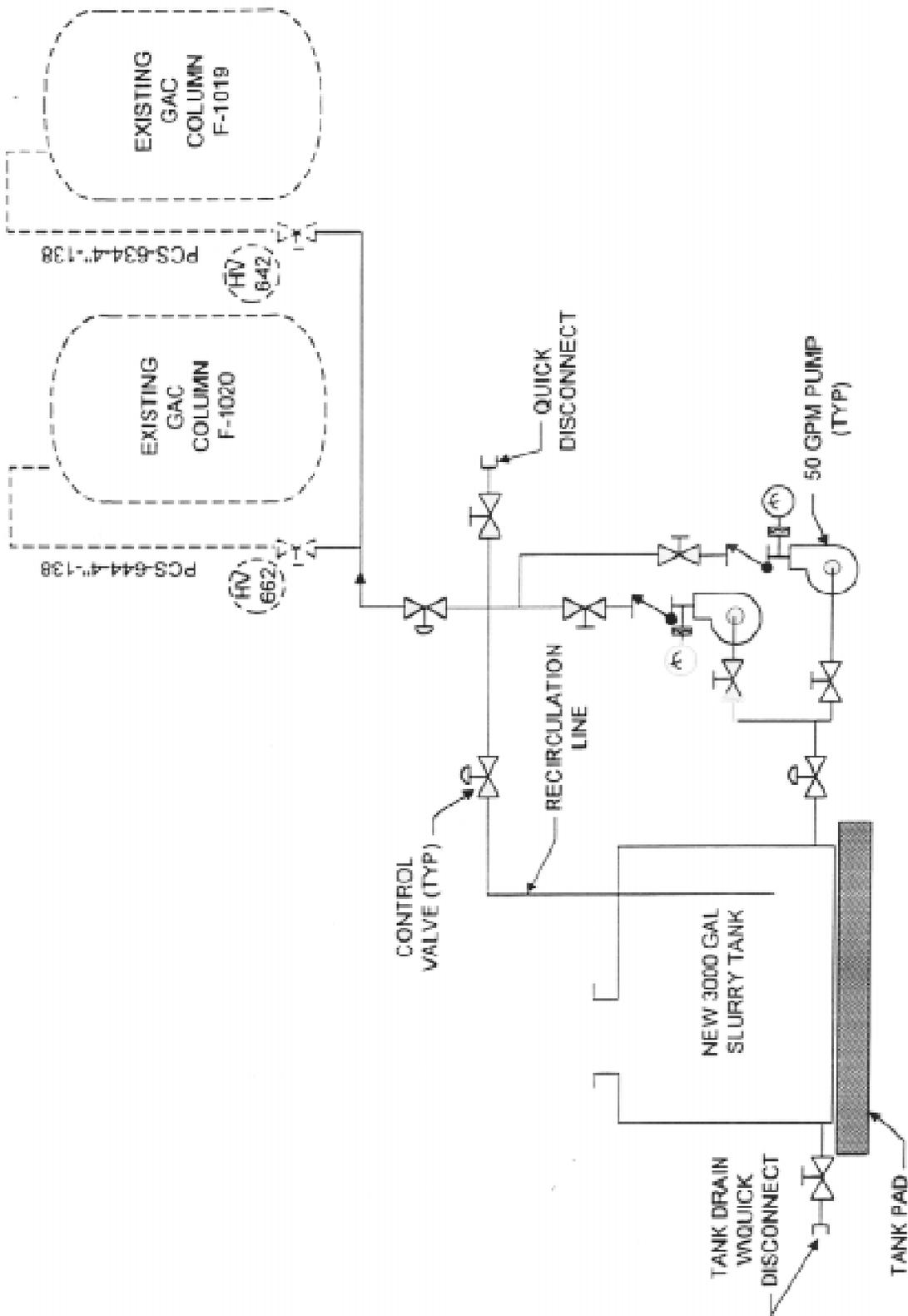


Fig. B.1. Slurry pumps and piping.

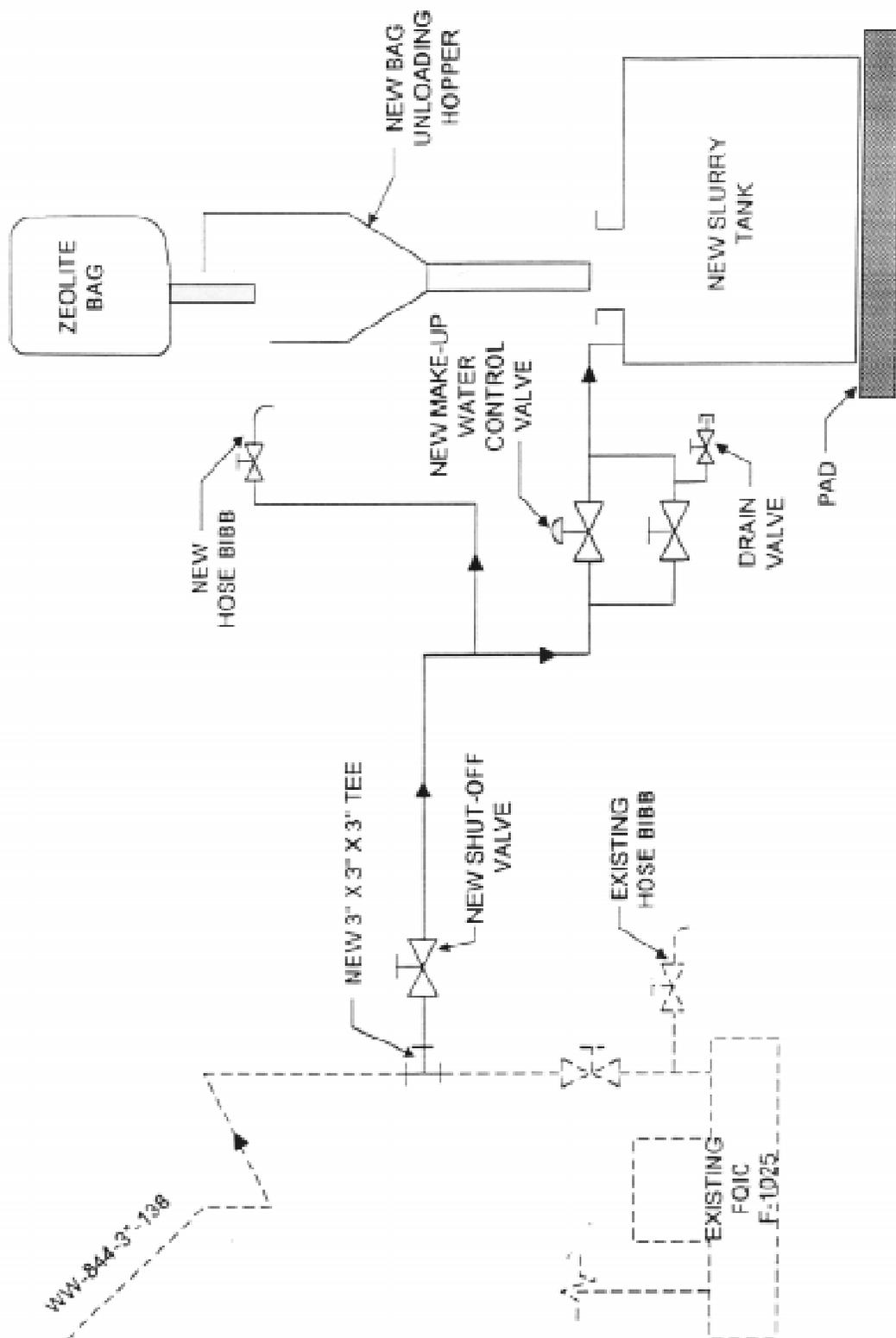


Fig. B.2. Process water for slurry tank.

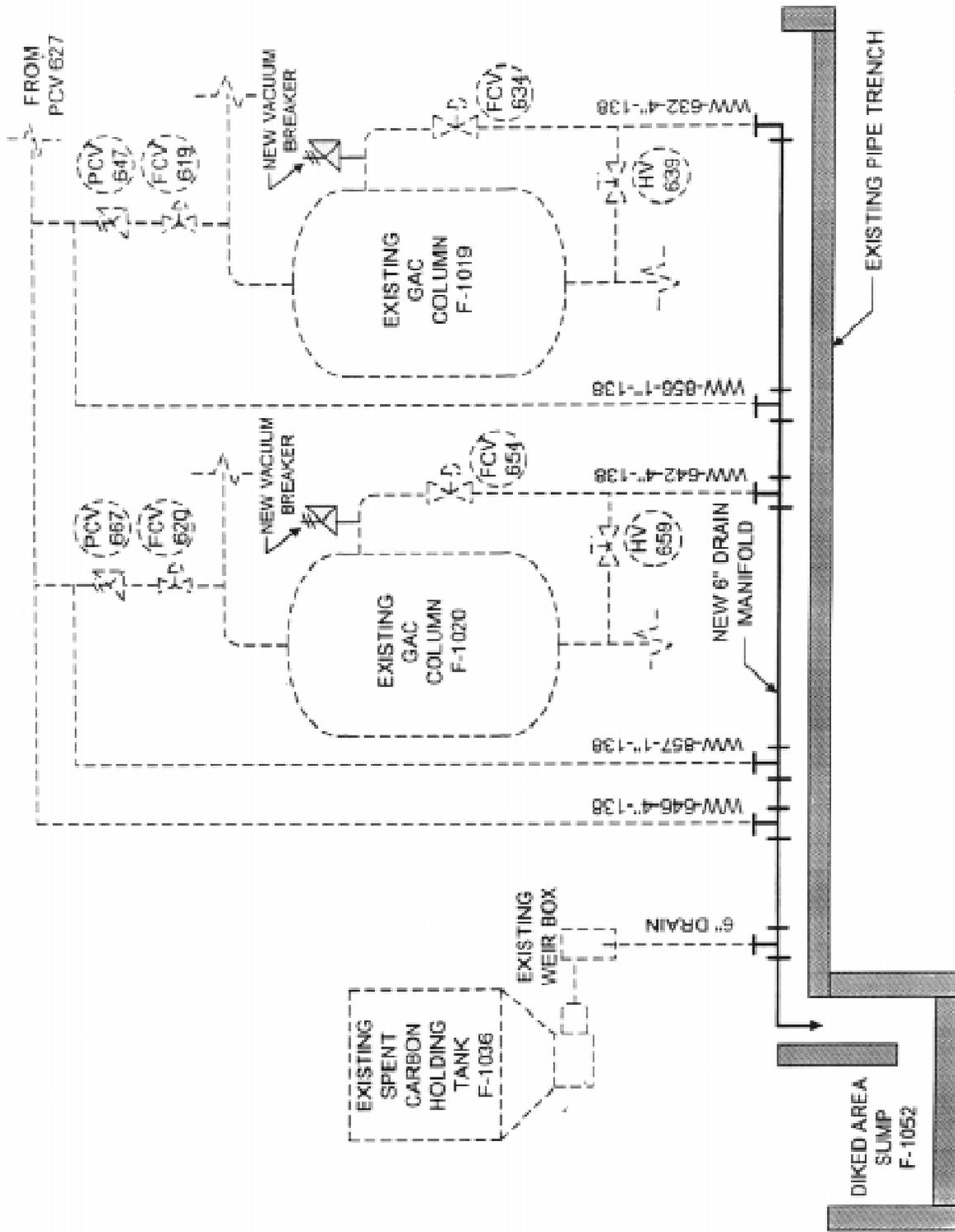


Fig. B.3. Modifications for tank drains.

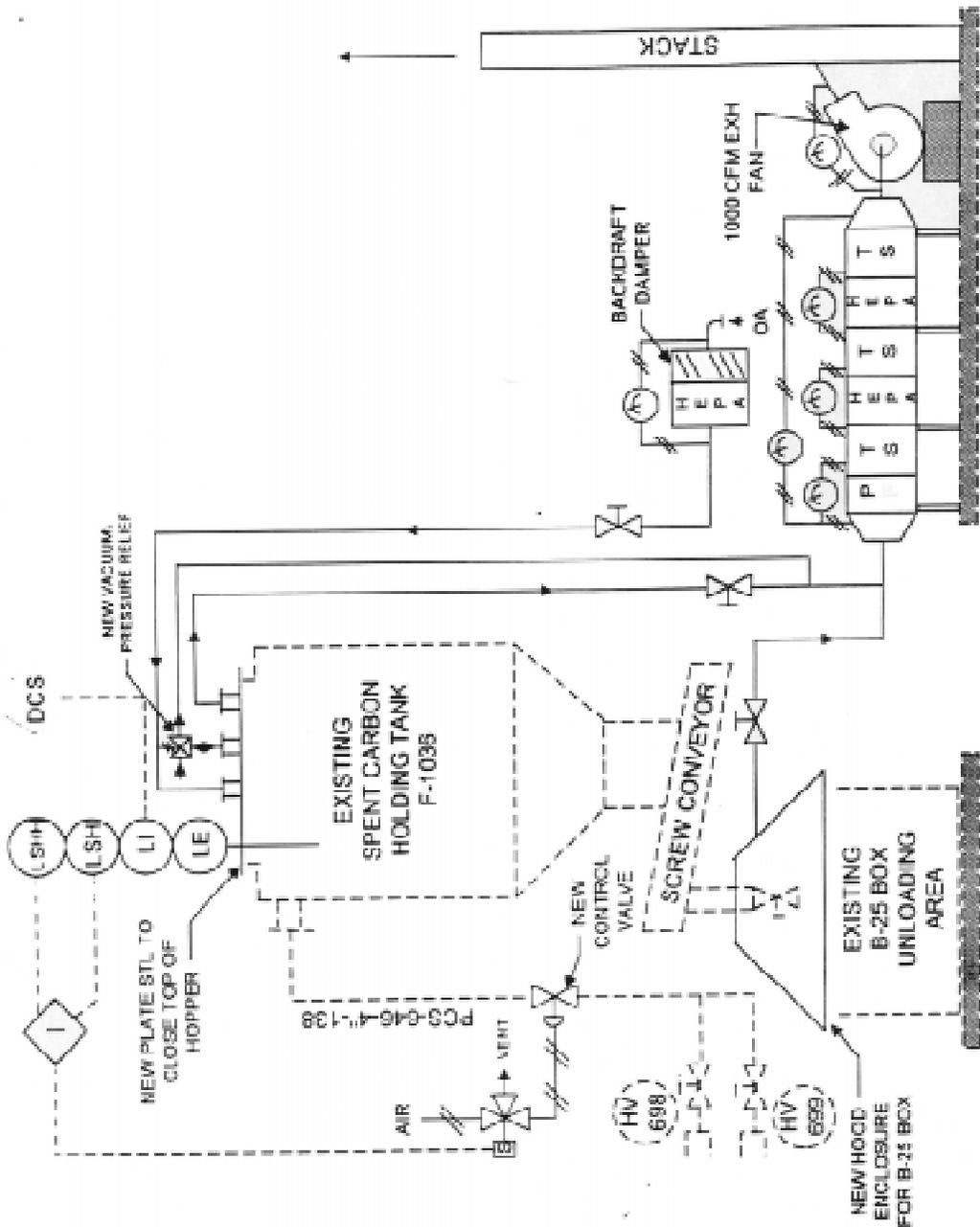


Fig. B.4. Exhaust system for spent carbon holding tank.

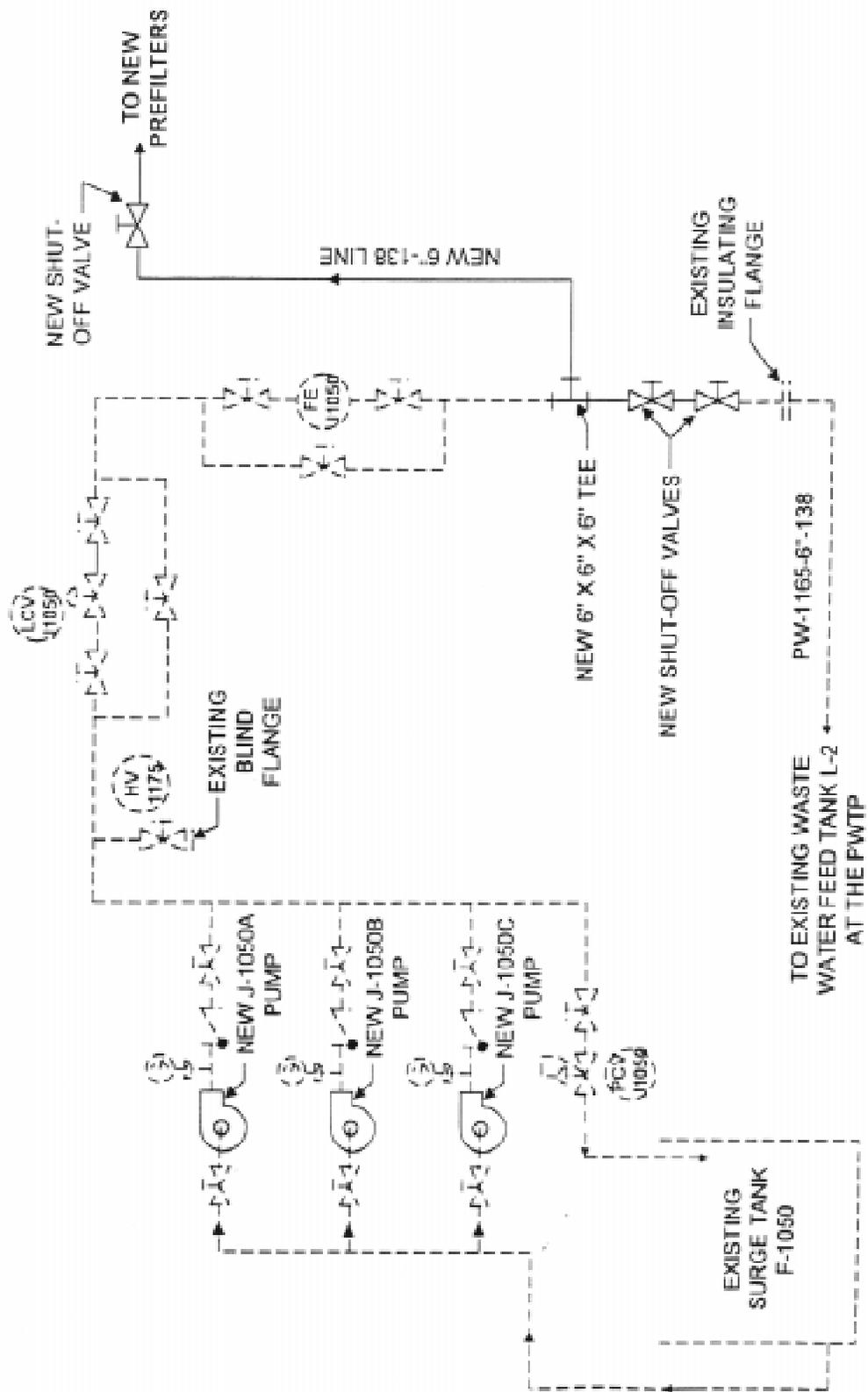


Fig. B.5. J-1050 pump and piping modifications for option 2.

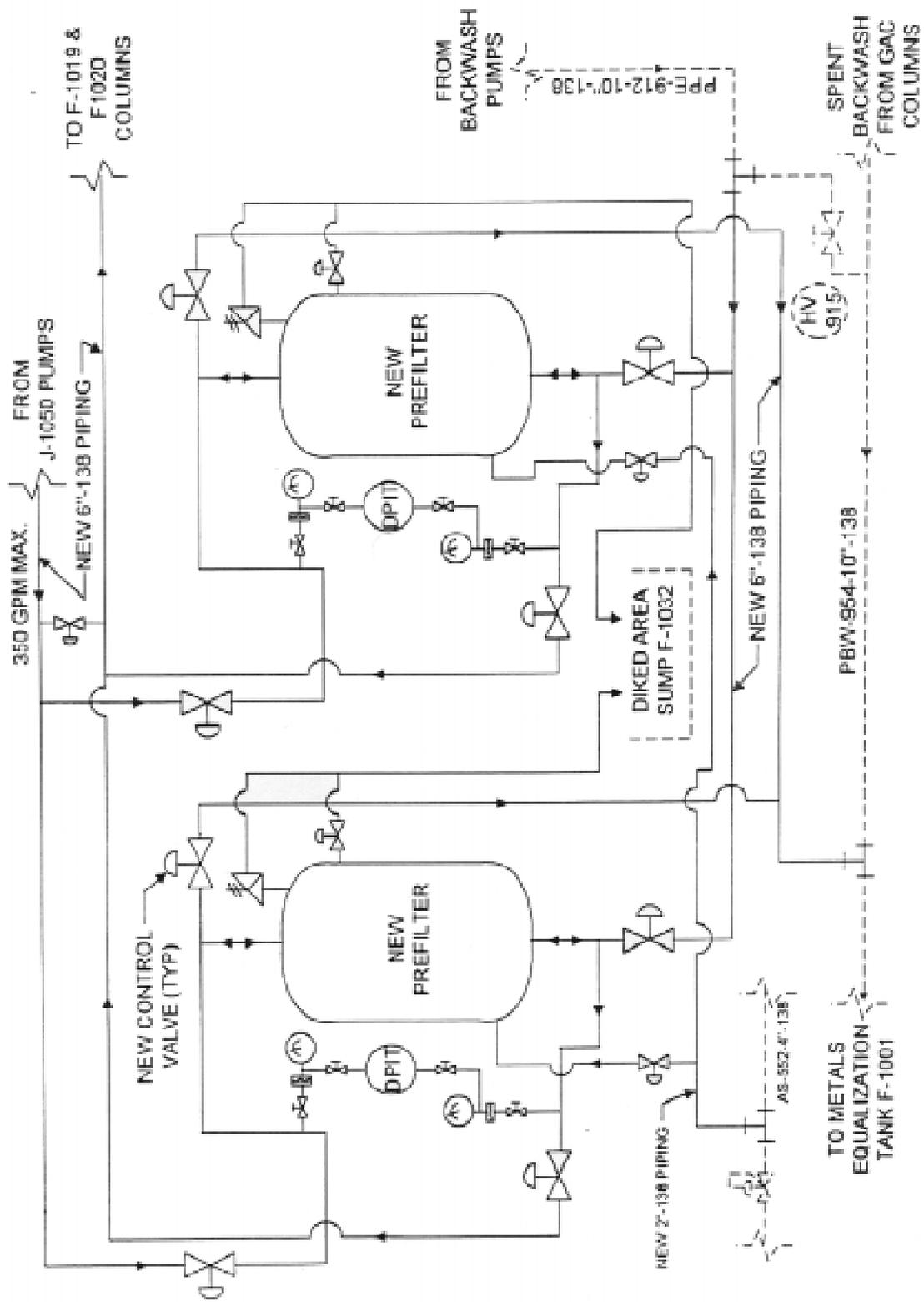


Fig. B-6. Option 2 new prefilter piping.

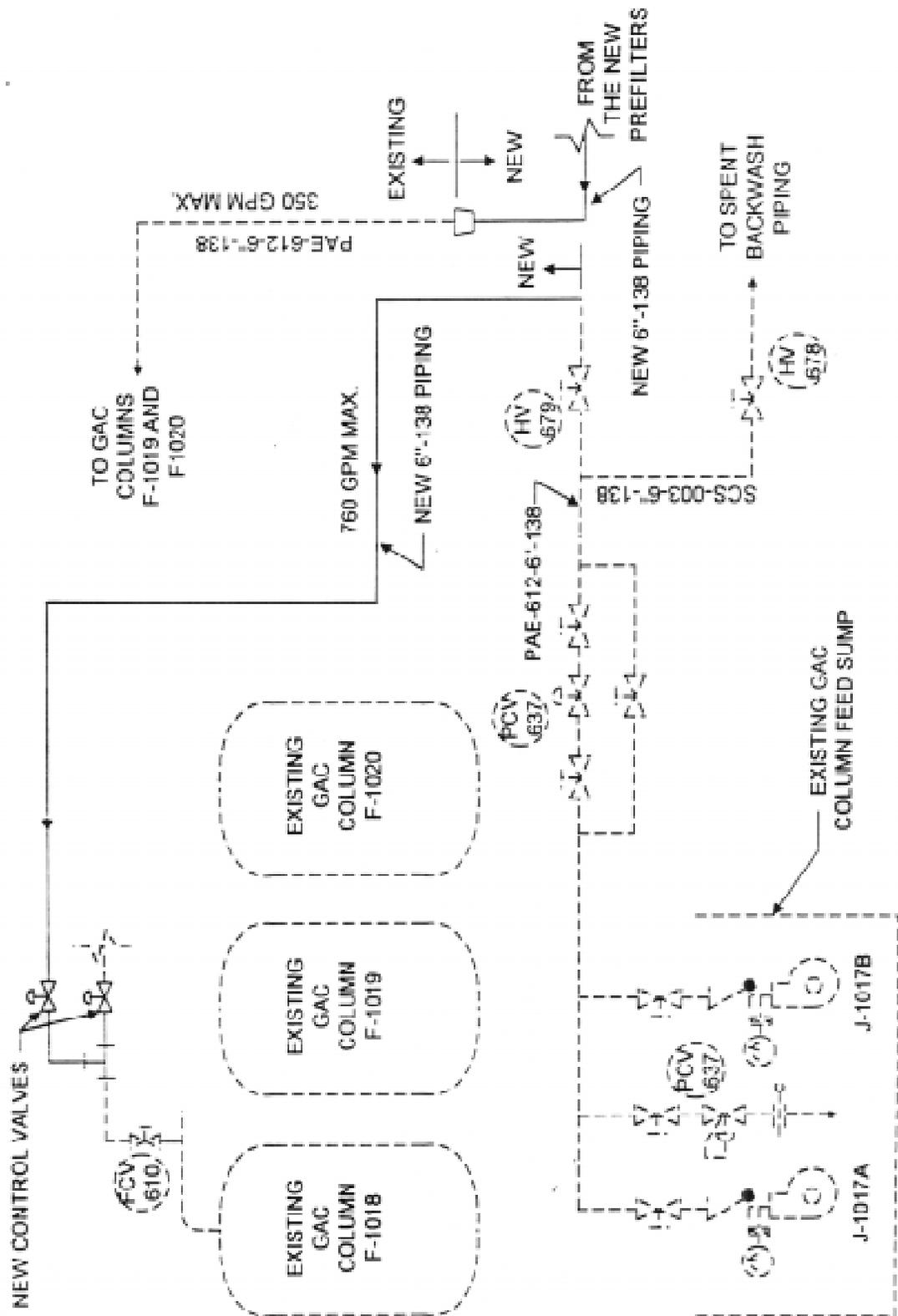


Fig. B.7. Option 2 modifications for GAC feed piping.

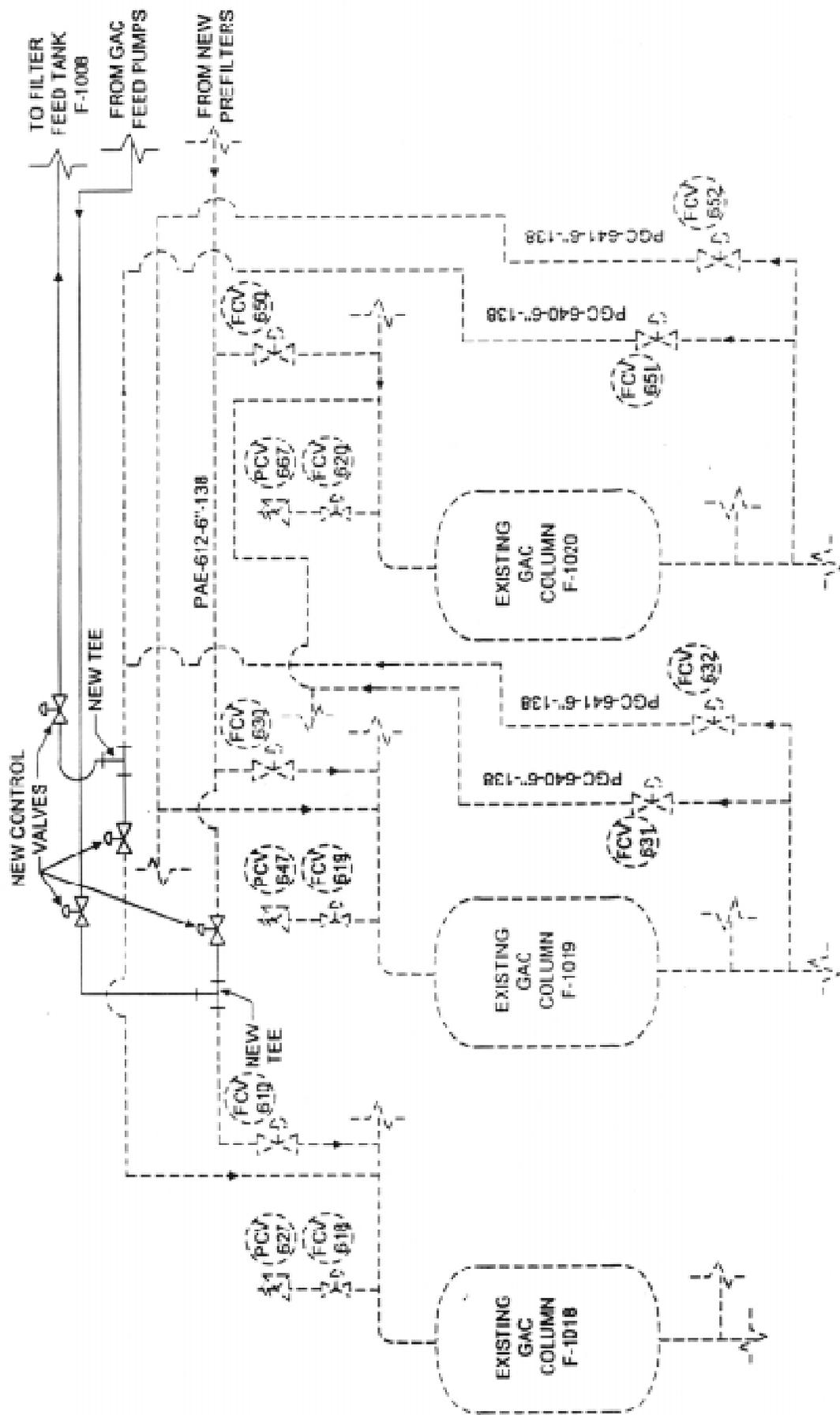


Fig. B.8. Option 2 modifications for GAC columns.

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