JUN 07 1999 20
JUN 15

ENGINEERING DATA TRANSMITTAL

Page 1 of 1
1. EDT 626920

2. To: (Receiving Organization) Distribution		3. From: (Originating Organization) NHC Sludge Treatment Project		4. Related EDT No.: N/A							
5. Proj./Prog./Dept./Div.: Spent Nuclear Fuel Project		6. Design Authority/Design Agent/Cog. Engr.: A. G. Westra		7. Purchase Order No.: N/A							
8. Originator Remarks: For Approval and Release				9. Equip./Component No.: N/A							
11. Receiver Remarks:		11A. Design Baseline Document? ☐ Yes ☒ No		10. System/Bldg./Facility: N/A							
				12. Major Assm. Dwg. No.: N/A							
				13. Permit/Permit Application No.: N/A							
				14. Required Response Date: N/A							
15. DATA TRANSMITTED				(F)	(G)	(H)	(I)				
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Design- nator	Reason for Trans- mittal	Origin- ator Dispo- sition	Receiv- er Dispo- sition			
1	HNF-4516	all	0	K Basin Sludge Treatment	N/A	2		1			
				Project Chemical							
				Processing Baseline							
				Time Diagram Study							
16. KEY											
Approval Designator (F)		Reason for Transmittal (G)			Disposition (H) & (I)						
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)		1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)			1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged						
17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)											
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1	1	Design Authority A. G. Westra	A. G. Westra	5-27-99	H0-34	1	1	T. A. Flamen	5-27-99	616799	H0-34
		Design Agent			H0-34	1	1	C. A. Petersen	5-27-99	616799	H0-34
1	1	Cog. Eng. S. C. Klimper	S. C. Klimper	5-27-99	H0-34	3		K. L. Pearce			H0-34
1	1	Cog. Mgr. W. W. Rutherford	W. W. Rutherford	5-27-99	H0-34	3		F. W. Moore			H0-34
		QA				3		SNF Project File			H0-34
		Safety				3		Central File		81-07	A3-00
		Env.				3		DOE/RL Reading Room		H2-53	H6-15
18. S. C. Klimper Signature of EDT Originator		19. W. W. Rutherford Authorized Representative for Receiving Organization		20. W. W. Rutherford Design Authority/ Cognizant Manager		21. DOE APPROVAL (if required) Ctrl No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments					

K BASIN SLUDGE TREATMENT PROJECT CHEMICAL PROCESSING BASELINE TIME DIAGRAM STUDY

S. C. Klimper

Numatec Hanford Corporation

Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 626920

UC: 2000

Org Code: 82500

Charge Code: 105619/B420 HN9A0121

B&R Code: 39EW04J10

Total Pages: 145 146

Key Words: time diagram, sludge treatment, K Basin, critical resource

Abstract: This document provides an initial basis for determining the duration of operating steps and the required resources for chemically treating K Basin sludge before transporting it to Tank Farms. It was assumed that all operations would take place within a TPA specified 13-month timeframe.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

James Aardal

6-7-99

Release Approval

Date

Release Stamp

Approved For Public Release

HNF-4516
Revision 0

K Basin Sludge Treatment Project
Chemical Processing Baseline
Time Diagram Study

Prepared by S. C. Klimper
Numatec Hanford Corporation

May 1999

TABLE OF CONTENTS

1.0	TIME DIAGRAM ALTERNATIVES ANALYSIS SUMMARY	1
2.0	TIME DIAGRAM PROBLEM STATEMENT	2
3.0	CONSTRAINTS AND ASSUMPTIONS.....	3
3.1	CONSTRAINTS	3
3.2	ASSUMPTIONS	3
3.2.1	Dissolver Assumptions	4
3.2.2	Adjustment Tank Assumptions	5
3.2.3	Centrifuge Assumptions	6
3.2.4	Grouting Assumptions	8
3.2.5	Resin Leaching Assumptions	8
3.2.6	Process Feed Supply and Handling	9
4.0	DECISION CRITERIA	11
5.0	ANALYSIS OF ALTERNATIVES.....	12
5.1	METHODS OF ANALYSIS	12
5.1.1	Microsoft Project Model Construction	12
5.1.2	Calculating Impact of Scheduled Downtime	13
5.1.3	Calculating Impact of Unscheduled Downtime	15
5.1.4	Calculating Resin Leaching Times	18
5.1.5	Calculating Grouting Times	20
5.2	DESCRIPTION OF STUDIED ALTERNATIVES	22
5.2.1	2 Adjustment Tank Alternative.....	22
5.2.2	3 Adjustment Tank Alternative.....	22
5.2.3	3 Adjustment Tank and 2 Dissolver Alternative.....	23
5.3	ALTERNATIVES SCREENED OUT	23
5.4	DATA COLLECTION AND GENERATION	24
5.4.1	2 Adjustment Tank Alternative.....	24
5.4.2	3 Adjustment Tank Alternative.....	27
5.4.3	3 Adjustment Tank and 2 Dissolver Alternative.....	30
5.5	EVALUATION AND ANALYSIS OF ALTERNATIVES AGAINST DECISION CRITERIA	33
5.6	PROGRAMMATIC RISK ANALYSIS	34
5.6.1	Sampling Turnaround and Adjustment Tank Risks	35
5.6.2	Process Feed and Product Transportation Risks	35
5.6.3	Sludge Volume Risks	35
5.6.4	Conditioned Solids Settling Risks	35
5.6.5	Other Risks	36
5.7	SENSITIVITY ANALYSIS	37
5.7.1	Sensitivities of 2 Adjustment Tank Alternative.....	38
5.7.2	Sensitivities of 3 Adjustment Tank Alternative.....	38
5.7.3	Sensitivities of 3 Adjustment Tank and 2 Dissolver Alternative.....	38
6.0	CONCLUSIONS	40
7.0	REFERENCES.....	42
APPENDIX A		43
APPENDIX B		53
APPENDIX C		80

APPENDIX D..... 107

APPENDIX E..... 134

1.0 TIME DIAGRAM ALTERNATIVES ANALYSIS SUMMARY

The K East (KE) and K West (KW) fuel storage basins at the 100 K Area of the Hanford Site contain sludge on the floor, in pits, and inside fuel storage canisters. HNF-2735, "K Basin Sludge Treatment Process Description" (Westra 1998) describes a chemical dissolution baseline process for treating the K Basin sludge. The purpose of this study is to provide enough information on the integrated operating time estimates of the proposed K Basin sludge treatment baseline process, to aid decision making with regards to quantities of resources. The acceptable operational timeframe for this baseline process is derived from sludge retrieval TPA milestones M-34-08 and M-34-10, and is 390 days. This study used the assumptions discussed in Section 3 and Appendix A to build time dependent models with a Microsoft Project platform. Based on information obtained from the optimization of these models an overall processing time was calculated for 3 resource quantity alternatives. The resource quantity alternatives considered in this study were chosen by determining the minimum resources necessary to complete processing within the specified timeframe. No effort was made to further reduce the total processing time. The three resource quantity alternatives analyzed in this study are the following:

- 2 Adjustment Tank Alternative
- 3 Adjustment Tank Alternative
- 3 Adjustment Tank and 2 Dissolver Alternative

The total processing times for these alternatives were calculated in two separate ways. The first includes the impact of scheduled downtime (maintenance/cleaning activities referred to as "Scheduled Cleanings"), and the second is without the impact of scheduled cleaning. The results of these calculations can be seen in Table 6-1 and 6-2. Table 6-1 shows the processing days, including scheduled cleanings, if 70% overall plant availability is assumed. Table 6-2 shows the processing days without scheduled cleanings, and adjusted to 60% overall plant availability. A comparison of these tables shows that assuming a 24-hour cleaning period every 10 batches and 70% overall plant availability has results similar to assuming no scheduled downtime and 60% overall plant availability. Figures X-1 and X-2 demonstrate the performance of the alternatives over a range of availability factors.

In Section 5.5 the 3 alternatives are evaluated against the weighted decision criteria from Section 4.0. The detailed results of this analysis can be found in Section 5.5, and a summary of the results can be seen in Table 6-3. From Table 6-3 it can be seen that for the chosen criteria at the specified weights, the **3 Adjustment Tank and 2 Dissolver alternative easily had the best score**. The primary driver for this was the significant weight given to total processing time as opposed to the much smaller weight given to the criteria measuring cost and operational complexity. With the minimal criteria used in this analysis, any change in weighting could cause a significant change in each alternative's score.

2.0 TIME DIAGRAM PROBLEM STATEMENT

The objective of this time diagram analysis is to compare resource quantities necessary to process the K Basin sludge within the TPA specified timeframe, and to provide sufficient information for the decision maker(s) to determine what resources the chemical processing baseline will require. The chemical processing baseline analyzed in this study is the process described in HNF-2735, "K Basin Sludge Treatment Process Description". "Resource quantities" refers to the quantity of a particular piece of equipment that will be required. An example would be to determine whether 1 dissolver or 2 dissolvers would be required. The assumptions used to define the time diagram will ultimately determine some of the performance criteria for various equipment, but this study will not address the specifics of those performance criteria.

This study will use a set of time constraints and assumptions to enter process steps and associated durations into Microsoft Project. The process steps will each be associated with a particular piece of major equipment, as found on the SNF Project Sludge Treatment System Process Flow Diagram, H-1-81170. Project will then be used to document and evaluate the times that each piece of equipment are estimated to be in use. Using this information, alternatives will be analyzed to determine how well they satisfy established criteria.

Information and a complete listing of the criteria for this study can be found in Section 4.0, but the primary ones are how long will it take to process all the sludge and what level of reliability and maintainability will be required.

3.0 CONSTRAINTS AND ASSUMPTIONS

3.1 Constraints

The only constraint considered in this study is that the TPA constraint that requires all sludge to be retrieved in a 13-month timeframe from July 31, 2004 to August 31, 2005. For this study, the TPA milestone is being interpreted to mean that all aspects of sludge processing must also be completed in this timeframe. This is assumed to include the grouting of treated solids and the used cartridge filters generated by the process. This interpretation of the TPA milestone is the conservative one, and it is expected that the only hard requirement is that sludge is retrieved by August 31, 2005.

3.2 Assumptions

The construction of a time diagram is based on the duration identified for each process step and the relationships of these steps to each other. In the case of a pre-conceptual process like the one being analyzed, the durations identified for each step are themselves assumptions. To formulate these time assumptions, a table was developed which attempted to define the major process steps. The major process steps were categorized according to the equipment in use for that step of the process. This developed into a rather extensive table. As a result of this, only those assumptions that help define the durations of critical resources will be discussed in this section. The complete table of assumptions can be found in Appendix A.

One overall assumption that impacts most areas of this time diagram study is that batches will not be commingled during processing. This applies to all process steps except where resins are collected and treated and the solids collection and grouting process. The main impact of this assumption is that the elutriation column is modeled as being run every batch. However, while this step delays the transfer of sludge from the Sludge Buffer Tank to the Dissolver, it does not effect any of the critical resource alternatives analyzed in this study. In other words, sludge would not necessarily be processed any faster by restricting this process step because other pieces of equipment already limit how close together batch starts can happen.

Other assumptions that impact all of the alternatives for all feed streams are the assumptions made about scheduled downtime. The impacts of scheduled downtime are discussed in Section 5.1.2, and are based on 3 assumptions. The first assumption is that scheduled maintenance or cleaning can take place while process products are still in the adjustment tanks. The second assumption is that the scheduled downtime will average 24 hours beginning to end. The third assumption is the scheduled downtime will happen once every 10 batches. Any significant changes to these assumptions could greatly impact the total processing times.

3.2.1 Dissolver Assumptions

The process steps identified in Table 3-1 with their associated time assumptions indicate that a dissolver could be in use anywhere from 20 to 36 hours per batch of sludge.

TABLE 3-1 DISSOLVER ASSUMPTIONS

Dissolve Sludge Process Steps	Assumptions
Add Initial Reagents to Dissolver (300-500 liters)	-Will do this in 30 minutes
Heat Dissolver Contents	-Assume 2 hours for this
Receive Sludge From Sludge Buffer Tank	-This will be spread out over 8 hours for safety considerations
Complete Reaction (additional reaction time required to complete reaction after receiving all feed from the Sludge Buffer Tank; dependent on particle size and feed composition)	-KE1: 4 hours -KE2: 16 hours -KW1: 2 hours -KW2: 20 hours -KW3: 12 hours
Cool Dissolver Contents	-Approximately 2 hours will be necessary for adequate cooling
Transfer Dissolver Contents to Centrifuge	-Transfers will occur at 1m ³ /hr -A transfer will be paused for flushing/washing whenever 18 kg of solids have been accumulated in the centrifuge (e.g., there will be 2 intermittent flushings per batch for KE1 feed and each flushing will take 55 minutes based on centrifuge assumptions); therefore the total time to <u>transfer a batch and empty the dissolver</u> is as follows: KE1: 233 minutes (2 intermittent flushings) KE2: 147 minutes (0 intermittent flushings) KW1: 360 minutes (5 intermittent flushings) KW2: 147 minutes (0 intermittent flushings) KW3: 147 minutes (0 intermittent flushings)

The most significant variable for a dissolver is the time required to sufficiently complete the desired reactions in the dissolver. These times have been estimated from ongoing laboratory work. The time required is dependent on particle size and feed composition, where the larger pieces of fuel are expected to take considerably longer to dissolve. If the feed is mostly metal oxides and insoluble components, it is expected to have smaller particle sizes and the reaction should go to completion much sooner.

The next assumption most responsible for the duration of the dissolution step is that the feed will be added to the dissolver gradually over an 8-hour period. This assumption does not currently vary from feed stream to feed stream, but since safety considerations are the driving force behind spreading the feed addition over an extended period of time, it is conceivable that different lengths of time could be used for the different feed streams.

The last dissolver assumption discussed here deals with centrifuge limitations. The volume of slurry sent from the dissolver to the centrifuge varies from 2.2 to 2.4 m³ per batch of feed processed. The limitation is that the centrifuge can only accept the slurry at 1.0 m³ per hour. This is further impacted by the fact that if 18 kg of solids have been sent to the centrifuge, the centrifuge must be shut down for a rinsing operation that lasts almost an hour. It is this last point that causes the durations for KE1 and KW1 to be so much higher than the other feed streams, due to the high level of insoluble materials contained in these streams.

3.2.2 Adjustment Tank Assumptions

The assumptions found in Table 3-2 lead to an adjustment tank being in use for over 50 hours per batch of feed. The most time consuming assumption made for the K Basin sludge treatment project is that sampling and getting the results back will take 2 full days. Sampling and waiting for results currently accounts for more than 93.9% to 95.1% of the time an adjustment tank is in use. The assumption on sampling is dependent on the final infrastructure, information required, and laboratory priorities. Any of these factors could greatly influence the sampling time in either a negative or positive fashion.

Table 3-2 Adjustment Tank Assumptions

Adjust Filtered Liquid Process Steps	Assumptions
Receive and Store Filtered Liquid	-No process restrictions -Will take same time that it takes to process liquid through cartridge filter, plus the 30 minutes to receive the filter rinse water
Sample and wait for results	-Depending on infrastructure, information needed, and priorities this could take anywhere from 5 hours to 10 days -Will assume 2 days for initial time diagram
Add Adjustment Reagents	-Time varies greatly depending on amount of adjustments reagents needed; 0-1300 liters depending on the batch -Will assume 1 hour needed to transfer maximum amount; This assumes no safety considerations restrict flow rate -If a small amount of reagents are necessary, it is assumed a minimum of 15 minutes will be required for operational requirements -Following are the estimated times for each feed stream: KE1: 2 liters, 15 minutes KE2: 1,010 liters, 48 minutes KW1: 1 liter, 15 minutes KW2: 1,279 liters, 60 minutes KW3: 1,121 liters, 53 minutes
Transfer Adjusted Liquid to Neutralization Tank	-Assume no flow restrictions and transfer can occur in 1 hour

The only other significant variable in the Adjustment Tank assumptions is the one about adding adjustment reagents. In determining these times it has been assumed that there will be no safety restrictions placed on the reagent addition rate. However, an assumption has been made that a minimum of 15 minutes will be required for this process step, no matter how small the addition. This was done to account for the actual physical steps required to perform the operation. For the KE1 and KW1 feed streams, it is expected that this step will not be required for all batches, but in developing the time diagram, this step has always been included. The 15-minute difference in Adjustment Tank usage is not a significant factor.

3.2.3 Centrifuge Assumptions

The set of assumptions used to define the duration of centrifuge operations can be found in Table 3-3. While the centrifuge is the critical resource for only one feed stream in one of the analyzed alternatives, its assumptions merit discussion for a couple of related reasons. First, the processing steps and time assumptions related to rinsing and declogging found in Table 3-3 were the ones used to build the time diagram alternatives, but since that time more accurate and detailed information about centrifuge rinsing and declogging operations has become available. However, the new information is based on a different processing plant and no final determination has been made about centrifuge operations for the SNF Sludge Treatment Project chemical processing baseline. Without a finalized operating scheme, the overall times assumed for that the rinsing and declogging operation could range from 45 minutes up to 2 hours. Secondly, if the rinsing and declogging operation is found to take 2 hours it could impact the time diagram for the KE1 alternative that uses 2 dissolvers and 3 adjustment tanks. All of the KE1 resource alternatives use 3 total flushings for the dissolver slurry centrifugation step and 3 more for the leached dissolver slurry centrifugation step. The centrifuge is currently modeled as being dedicated to a KE1 batch for less than 13 hours, but if the rinsing and declogging operation assumptions are changed to the longer times it could add more than 6 hours to this time.

Table 3-3 Centrifuge Assumptions

Centrifuge Dissolver Slurry	
Clarify Dissolver Slurry	<p>-Dissolver slurry will be received at 1m³/hr; based on this and flushing/washing assumptions below, the total time to <u>clarify a batch of dissolver slurry</u> is as follows:</p> <p>KE1: 283 minutes (3 flushings total) KE2: 197 minutes (1 flushing total) KW1: 410 minutes (6 flushings total) KW2: 197 minutes (1 flushing total) KW3: 197 minutes (1 flushing total)</p>
Transfer Liquids to Clarified Liquid Tank	-No process restrictions; can occur at whatever rate the centrifuge produces clarified liquid
Stop Centrifuge When 18 kg of Solids Retained in Bowl or Done Clarifying Dissolver Slurry	-Clarification will be paused for flushing/washing whenever 18 kg of solids have been accumulated in the centrifuge (e.g., there will be 3 flushings total per batch for KE1 feed), minimal time (5 minutes) needed to stop centrifuge and prepare for flushing process
Flush Solids Cake with Water	-Can do this in 5 minutes (60 liters)
Homogenize Solids Cake and Water	-Can do this in 5 minutes
Recentrifuge Homogenized Slurry	-Can do this in 10 minutes
Flush Solids Cake With Water	-Can do this in 5 minutes (60 liters)
Homogenize Solids Cake and Water	-Can do this in 5 minutes
Transfer Centrifuged Dissolver Slurry to Leaching Tank	-Can do this in 5 minutes
Prepare Centrifuge for more feed	-Can do this in 5 minutes
Centrifuge Leached Dissolver Slurry	
Clarify Leached Dissolver Slurry from Leaching Tank	<p>-Leached Dissolver slurry will be received at 1m³/hr; based on this and flushing/washing assumptions below, the total time to <u>clarify a batch of leached dissolver slurry</u> is as follows:</p> <p>KE1: 199 minutes (3 flushings total) KE2: 65 minutes (1 flushing total) KW1: 402 minutes (6 flushings total) KW2: 66 minutes (1 flushing total) KW3: 58 minutes (1 flushing total)</p>
Flush Solids Cake With Water	-Can do this in 7 minutes (75 liters)
Transfer Leached/Flushed Dissolver Slurry to Solids Reception Tank	-Can do this in 5 minutes

The only assumptions listed for centrifugation of the leached dissolver slurry are those that are different than the assumptions used for the dissolver slurry. All the other steps are the same.

3.2.4 Grouting Assumptions

A significant assumption made to simplify processing the K Basin sludge is that all the leached solids can be collected together in the Solids Reception Tank until all sludge processing is done. This amounts to more than 50 m³ of slurry that will need stored (Westra 1998). Inherent to this assumption is the expectation that after all 50+ m³ of slurry are collected, the solids can be allowed to settle, more than 33 m³ of water decanted, and still be able to homogenize the remaining 41 wt% slurry for sampling and processing.

The first step in grouting the conditioned solids will be to transfer the decanted liquid to the clarified liquid tank. Because the expected volume of decanted liquid is more than 33 m³, the decanting process will have to occur in phases. Previous to this step, the largest nominal volume transferred into the clarified liquid tank is 5,349 liters (Westra 1998), during the processing of feed stream KW1. In order to expedite the processing of the conditioned solids it is being assumed the 33+ m³ can be transferred and processed in 6 batches. This will require transfers into the clarified liquid tank of 5,500 – 5,600 liters.

Other process related assumptions are that there will be no cartridge filter rinsing or change out required during the processing of the decanted liquid, since the mass balances in the process description (Westra 1998) contain totals of zero for these streams. The other assumption based on the values in the process description document is that no adjustment will be required before neutralizing the solution for transport to tank farms.

A final, but significant, grout related assumption is that storage and grouting of used cartridge filters can happen concurrently with sludge processing operations. Based on this assumption the grouting of used cartridge filters would have no impact on the derived processing times for this study, and therefore is documented only in the assumptions in appendix A.

A list of all the assumptions related to grouting can be found in Appendix A.

3.2.5 Resin Leaching Assumptions

The assumptions in Table 3-4 apply to all of the light phase coming out of the elutriation column, not just the organic resin beads. However, the organic ion exchange resin beads do comprise a significant portion of the elutriation column's light phase for the overall process and are found primarily in feed stream KE1. The elutriation column's light phase for KE1 makes up approximately 95% of the overall process total. That is why resins (i.e., light phase from elutriation column) are modeled as being processed every 10 batches for KE1, but only once for the 22.4 batches of KE2, and only once more for all 43.8 batches of KW Basin sludge. As a result, these assumptions have the greatest

impact on the processing durations derived for KE1. Based on these assumptions and those in Appendix A, it was determined that resin leaching took approximately 72 hours beginning to end for KE1. Because of the minimal impact, only two other resin leaching batches besides KE1, this 72 hour value was used to determine the overall durations for all feed streams. In reality, because of lower volumes and solids content, the time to process the elutriation column's light phase for KE2 and all of KW will be less, but the difference is less than 1 day for the life of the process.

Table 3-4 -- Resin Leaching Assumptions

Store Resin (Resin Buffer Tank)	
Store Resins	<ul style="list-style-type: none"> -Will store up to 10 batches worth of light phase from the Elutriation Column for KE1 (this is approximately 108 kg of solids and 514 liters of slurry) before sending to the Leaching Tank -Will receive and store the light phase from all batches of KE2 (40.2 kg solids, 173 liters of slurry) before sending to the Leaching Tank -Will receive and store the light phase from all batches of KW1, KW2, and KW3 together before sending to the Leaching Tank (approximately 42 kg of solids)
Homogenize Resins	-This will take 15 minutes, or less
Transfer Resins to Leaching Tank	<ul style="list-style-type: none"> -This can be done in 30 minutes -Won't start until adequate amount of resins have been accumulated and the Leaching Tank is done being used to leach centrifuged dissolver products
Leach Resin Buffer Tank Contents	
Receive Resin Slurry from Resin Buffer Tank	<ul style="list-style-type: none"> -Assume this can be done in 30 minutes -Resins will only be leached when a sufficient mass of solids has been collected in the Resin Buffer Tank; Assume once every 10 batches for KE1, one time total for KE2, and one time total for all of KW1, KW2, and KW3
Add Leaching Reagents	-Can do this in 30 minutes
Homogenize Resin Slurry to Aid Leaching	-Assume this will take 4 hours
Transfer Leached Resin Slurry to Centrifuge	<ul style="list-style-type: none"> -Transfers will occur at 1m³/hr -A transfer will be paused for flushing/washing if 18 kg of solids have been accumulated in the centrifuge

3.2.6 Process Feed Supply and Handling

The most significant process feed assumption made for this time diagram study is that process feed will be available anytime it is needed. As the Microsoft Project models discussed in Section 5.0 were being constructed and optimized, it was always assumed that when the model called for Basin sludge to be transferred to the process it would be

available. This time diagram study did not attempt to define lag storage requirements or determine how sludge transfers from the basin would affect the lag storage system.

The assumptions in Table 3-5 only document the need for a sludge off-load system to be capable of transferring a batch of slurry containing 160 kg of solids into a lag storage tank in 1 hour. A fallout of the Microsoft Project models optimization is the additional requirement that the sludge retrieval, transfer, and off-load systems be capable of supplying a batch of slurry every 17 hours for the best case. It is assumed that future transport and facility studies will define the number of lag storage tanks necessary to meet these requirements, based on the integration of the proposed retrieval, transfer, and process systems.

Table 3-5 – Process Feed Assumptions

Store Process Feed	
Receive Sludge	<ul style="list-style-type: none"> -Full feed batch received in one shipment -Transferred in 1 hour -Feed available from Sludge Removal any time it is needed
Homogenize Feed	<ul style="list-style-type: none"> -Can be adequately mixed within 10 minutes of completing transfer
Feed Screening Process	<ul style="list-style-type: none"> -No process restrictions; All process feed sent to screen in 1 hour

4.0 DECISION CRITERIA

The evaluated alternatives are all based on the assumptions described in Section 3.0 and Appendix A. The only differences between the major alternatives are the total amount of time needed to process the K Basin sludge, specific process step times, and definition of how many of what pieces of equipment are in use. Because of this a limited number of decision criteria have been identified for this evaluation. The criteria can be found in Table 4-1.

Table 4-1 -- Time Diagram Decision Criteria

Decision Criteria	Criteria Weighting	Comments
1. The amount of time the analyzed alternative takes to complete processing of all sludge. The measured value will be the one that includes scheduled cleanings, and is unadjusted for plant availability.	50%	The less time it takes an alternative to process all sludge, the better its grade will be for these criteria. If an alternative's raw number is greater than 350 days, it will be screened out from further analysis.
2. The availability estimate required for the analyzed alternative to achieve compliance with criteria 1 (Process all sludge in less than 350 days).	30%	The more conservative the availability estimate can be for the alternative, the better its grade will be for these criteria.
3. The amount of duplicate equipment required.	20%	If more equipment is required to meet processing goals, the project will be more expensive. Operation will also be more complicated. Therefore, the less equipment an alternative has, the better its grade will be for these criteria.

The weights applied to the criteria in Table 4-1 are based on the restricted timeframe the TPA allows for K Basin sludge removal. The constrained timeframe of the TPA also precludes the analysis of any alternative that would take more than 350 days to process the K Basin sludge. This is because of the need to incorporate overall plant availability factors into the analysis, and because of the possibility that the TPA could be modified or interpreted to mean all aspects of sludge removal and treatment will be completed within the 13-month timeframe.

The grade given an alternative for each criterion will range from 0-10 and be comparative to the other alternatives. For instance, the first criteria will be graded on a 150-350 processing day range, with 150 days receiving 10 points and 350 days receiving 0 points. The grade for the second criteria will be similar with 50% availability receiving 10 points and 90% availability receiving 0 points. The grade for the third criteria will be more subjective, with judgement being used to evaluate the cost and operating impacts of adding the additional equipment.

5.0 ANALYSIS OF ALTERNATIVES

5.1 Methods of Analysis

This analysis was performed in two distinct steps. The first step was to build models in Microsoft Project using the assumptions discussed in Section 3.0 and found in their entirety in Appendix A. A separate model was needed for each process feed stream correlated to each studied alternative. With 5 distinct feed streams and 3 resource quantity alternatives, 15 separate models were required. These models were then used to identify the critical resource for each alternative and to determine the minimum amount of time required between the starts of batches. Additional models were required to determine the length of time required for resins leaching and grouting of the treated solids. Details on the Microsoft Project models can be found in the Appendices.

The second step was to use the information from the models to calculate a total processing duration for each stream and an overall total for each alternative. The total duration includes determining the effects of scheduled and unscheduled downtime, resin leaching, and grouting of treated solids.

5.1.1 Microsoft Project Model Construction

The first thing required for the construction of sludge processing models in Microsoft Project was a list of all envisioned process steps listed in the anticipated sequence. The process steps were then grouped by the particular piece of equipment required for that step. Finally, estimated durations were assigned to each assumption resulting in the tables found in Section 3.0 and Appendix A.

The process steps and their durations were then entered in Microsoft Project in their anticipated sequence. This process was complicated by the determination of when steps could start in relation to previous steps, and the fact that it was necessary for some steps to be repeated at intervals dictated by other process steps. However, the use of these “predecessors” in Microsoft Project allowed the model to indicate the actual amount of time that a piece of equipment would either be in use, or at least occupied by products of the various process steps.

After building a model for 1 batch, the process was duplicated in order to add the processing of 5 more batches to the model. The total time required to process these 6 batches was then optimized in terms of “hours between batch starts”. This optimization was accomplished by bringing the starts of batches as close together as possible without causing any piece of equipment to operate at greater than 100% availability.

The model was then used to generate the data necessary to complete calculation of an overall processing time for each feed stream within the constrictions of each alternative.

5.1.2 Calculating Impact of Scheduled Downtime

The effect of scheduled downtime was calculated by determining the starting and ending times of multiple batches, determining when a scheduled downtime could begin, and comparing the totals with scheduled downtime to totals that didn't include a scheduled downtime. This was accomplished in the following manner using the 2 adjustment tank alternative and stream KW1 as an example:

From the model of feed stream KW1 being processed by the 2 adjustment tank alternative the following data was obtained:

26 hours between the starts of batches of sludge
36 hours to get batch completely into an adjustment tank
85 hours until a batch is completely out of an adjustment tank
98 hours beginning to end (batch is in TWRS waste tank)

Using the equation

$$(n-1) * (\text{time between batch starts}) = \text{start time of batch } n \quad (\text{Eqn. 5-1})$$

it can be derived that batch 10 would start at hour 234. It has been assumed that a scheduled downtime for cleaning, flushing, and minor maintenance would be implemented once every 10 batches. These scheduled downtimes are simply referred to as "cleanings" for the balance of the document. The cleanings are modeled to start after the 10th batch is completely into an adjustment tank. The cleaning is then expected to last 24 hours, at which point sludge processing could resume with the start of the 11th batch.

In this example, cleaning would start 36 hours (time to get batch completely into an adjustment tank) after batch 10 starts. This is hour 270, and the cleaning would then end at hour 294. Batch 11 could then start at hour 294.

However, if there were no cleanings assumed, the start time of batch 11 would be calculated as hour 260 using equation 5-1. The two different start times for batch 11 are then used to determine that cleaning adds 34 hours (294 hours – 260 hours) to the start time of each 10 batch set, or 3.4 hours per batch. The 3.4 hours per batch value can then be added to the original hours between batch starts of 26 hours to derive the "new batch start equivalent" of 29.4 hours.

The new batch start equivalent can then be used in equation 5-1 to determine the total processing time required for the estimated 11.2 batches of sludge in feed stream KW1 using the 2 adjustment tank alternative. This is done as follows:

$$(11.2 \text{ batches} - 1) * (29.4 \text{ hours/batch}) = 299.9 \text{ hours to start batch 11.2}$$

If batch 11.2 starts at hour 299.9, it is then completely in an adjustment tank by hour 335.9, and safely shipped and off-loaded at tank farms by hour 397.9. This is the equivalent of 16.6 days to process feed stream KW1 using the 2 adjustment tank alternative and assuming a cleaning every 10 batches. This value is unadjusted for availability.

To see the overall impact of cleanings, the total processing time can be calculated for the same alternative without cleanings. Without cleanings, determine the start time of batch 11.2 using equation 5-1 as follows:

$$(11.2 \text{ batches} - 1) * (26.0 \text{ hours/batch}) = 265.2 \text{ hours to start batch 11.2}$$

If batch 11.2 starts at hour 265.2, it is then safely shipped and off-loaded at tank farms by hour 363.2. This is the equivalent of 15.1 days to process feed stream KW1 using the 2 adjustment tank alternative and assuming no cleanings. This value is unadjusted for availability.

Therefore, cleanings add 1.5 days to the unadjusted processing time of KW1 when using the 2 adjustment tank alternative. It should be noted that as the other alternatives decrease the time between batch starts, the impact of scheduled cleanings increases on a per batch basis (See Table 5-1). However, since scheduled cleaning and maintenance would be expected to give a better availability factor, a comparison is made in the next section between better availability factors with cleaning, and poorer availability factors without cleaning.

Table 5-1 – Affects of Scheduled Downtime

<i>Time added per batch by cleaning for each feedstream (hours)</i>	2 Adjustment Tank Alternative	3 Adjustment Tank Alternative	3 Adjustment Tank and 2 Dissolver Alternative
KE1	2.9	3.5	3.6
KE2	3.2	3.2	4.6
KW1	3.4	3.9	4.1
KW2	3.2	3.2	5.0
KW3	3.2	3.2	4.3

5.1.3 Calculating Impact of Unscheduled Downtime

Calculating the impact of unscheduled downtime in this scenario is simply a matter of applying an availability factor to the unadjusted value derived in Section 5.1.2, 16.6 days to process feed stream KW1 using the 2 adjustment tank alternative and assuming a cleaning every 10 batches. This is demonstrated as follows:

$$(\text{Total Days}) * (\text{Availability Factor}) = (\text{Unadjusted Processing Days})$$

which then converts to

$$(\text{Unadjusted Processing Days}) / (\text{Availability Factor}) = (\text{Total Days})$$

Applying this to the demonstration case results in:

$$(16.6 \text{ days}) / (.60 \text{ availability factor}) = 27.7 \text{ total processing days at } 60\% \text{ availability}$$

or

$$(16.6 \text{ days}) / (.70 \text{ availability factor}) = 23.7 \text{ total processing days at } 70\% \text{ availability}$$

This second value can then be compared to the total processing days required for a model with no scheduled cleanings, but at only 60% availability, in the following manner:

$$(15.1 \text{ days}) / (.60 \text{ availability factor}) = 25.2 \text{ total processing days at } 60\% \text{ availability}$$

For this case it can be determined that more than 10% availability is gained by regularly scheduled cleaning and maintenance, but this results in only 1.5 days being gained because of the time needed for cleaning. For other cases the results are similar, with 70% availability and scheduled cleanings being roughly equivalent (+/- 5%) to 60% availability and no scheduled cleanings.

This calculation was repeated for a range of availability factors, with the results shown in Figures 5-1 and 5-2.

These calculations were replicated using Microsoft Excel, and all the results are reported in Section 5.3 and the appendices, along with other pertinent data.

Figure 5-1 -- Graph of Processing Days vs. Availability Factor with Scheduled Cleanings Included

Sludge Processing with Scheduled Cleanings

Figure 5-2 -- Graph of Processing Days vs. Availability Factor Without Scheduled Cleanings

Sludge Processing Without Scheduled Cleanings

5.1.4 Calculating Resin Leaching Times

The process of leaching resins is similar to that of processing sludge, except the process starts with the transfer of slurry from the Resin Buffer Tank into the Leaching Tank. From the Leaching Tank to the transport of slurry to Tank Farms and the transfer of treated solids to final conditioning, the process is identical in structure in the Microsoft Project model. The only things that vary are the times assigned to the process steps. Therefore, using the Microsoft Project model for resin leaching it was determined that it would take 72 hours beginning to end to process a batch of resins from the KE1 feed stream. The 72 hour value will also be used for the KE2 and KW1, 2, and 3 batches even though they would be expected to take 1 to 2 hours less processing time based on solids content.

Using process feed stream KE1 and the 2 Adjustment Tank Alternative as an example, it is first noted that, per the assumptions, resins will be leached once every ten batches for KE1. In a manner similar to that outlined in Section 5.1.2 the following start times for batch 11 can be derived:

Batch 11 with resin leaching & cleaning would start at hour 314

Batch 11 with no resin leaching or cleaning would begin at hour 260

Since the impact of scheduled downtime shown in Table 5-1 was calculated assuming that resin leaching would take place before cleaning, the start time of batch 11 that must be derived to determine the impact of resin leaching is the one where there is resin leaching, but no cleaning. The first step in determining this is to derive from the models when the resin leaching process could begin in relation to the previous batch of sludge. Using the 10 batch example and the models it can be determined that, based on adjustment tank availability, the resin leaching process can begin 48 hours before the end of batch 10. Since batch 10 starts at hour 234 and ends at hour 327, this means resin leaching begins at hour 279.

Using the models, it is determined that the resin leaching products are out of the leaching tank, centrifuge, and clarified liquid tank 12 hours after starting the resin leaching process. It is also found that the resins are out of the resin buffer tank 1 hour after starting the resin leaching process. Equally important is determining that Batch 11 of the sludge will need the leaching tank, centrifuge, and clarified liquid tank 18 hours after starting, and the resin buffer tank 2 hours after starting.

Using this data, it is then determined that based on leaching tank, centrifuge, and clarified liquid tank availability, batch 11 could start at hour 273 (hour 279 start time + 12 hours to vacate equipment – 18 hours equipment needed after starting). In the same way it is determined that based on resin buffer tank availability, batch 11 could start at hour 278 (hour 279 start time + 1 hour to vacate equipment – 2 hours equipment needed after starting). However, since this alternative only has 2 adjustment tanks, and batch 10 starts

at hour 234 and is out of the adjustment tank batch 11 will require at hour 315, batch 11 could start 30 hours before the adjustment tank is available. This would have batch 11 starting at hour 285. From all of this it can be seen that the earliest batch 11 could start is hour 285.

Calculating the time impact of leaching resins is then accomplished in a manner similar to the cleaning time impact discussed in Section 5.1.2. Batch 11 with resin leaching (no cleaning) can start at hour 285, and batch 11 with no resin leaching or cleaning can begin at hour 260. Therefore, the time added by processing resins for feed stream KE1 is 25 hours (285 hours – 260 hours) for a 10 batch set, or 2.5 hours per batch.

To simplify the replication of this calculation in Microsoft Excel and to make it more compatible with the other calculations, it was decided that a value called “Total Processing Hours Added By Resin Processing” should be calculated for each feed stream for each alternative. This was done in the following manner:

$$(\# \text{ of batches}) * (\# \text{ of hours added by resin processing} / \text{batch}) = \text{total time added by resins}$$

Continuing the previous example, it can be shown that

$$(146.1 \text{ batches}) * (2.5 \text{ hours added} / \text{batch}) = 365 \text{ total hours}$$

For the 2 Adjustment Tank Alternative to process feed stream KE1, there are 365 hours added to the total feed stream processing time by the processing of resins.

Based on the assumptions discussed in Section 3.2 and Appendix A, this calculation was only done for KE1, KE2, and following KW3. Since the light phase from the elutriation column will be stored for all batches of K West Basin sludge, it has been assumed that they will be processed in order and that the final batch of resin processed will take place following the processing of feed stream KW3. The results of these calculations can be found in Table 5-2.

Table 5-2 – Resin Leaching Impacts

Total Time added by Resin Leaching (hours)	2 Adjustment Tank Alternative	3 Adjustment Tank Alternative	3 Adjustment Tank and 2 Dissolver Alternative
KE1	365	132	278
KE2	17	9	13
KW3	21	9	15

5.1.5 Calculating Grouting Times

The calculation of the time required to grout treated solids was broken into two parts. The first part is the process of decanting excess liquid and processing it for transport to tank farms. The second part is then the grouting of the remaining slurry. This “calculation” was accomplished in a different manner than those previously described. Based on the assumptions found in section 3.2.4 and Appendix A, as well as the data contained in Westra (1998), the whole grouting process can be accomplished with the processing of 6 batches of excess liquid and the filling and transport of 7 grout liners. Because of the limited nature of this process, the Microsoft Project model built to represent the grout process was expanded to model all steps, assuming an alternative with 3 adjustment tanks is in use. Figure 5-3 shows all the summary steps, their durations, and the availability and use of the required resources. An evaluation of this model shows that the whole process will take about 30 days. This has not been adjusted for overall plant availability or reliability.

5.2 Description of Studied Alternatives

The three analyzed resource quantity alternatives are identical in structure for a given feed stream. In other words, the time required to complete specific process steps does not vary from one alternative to another for a given feed stream. The addition of duplicate equipment allows the structure to be further condensed or optimized, which results in reduced times between the start of batches. This might also result in a change of the critical resource for a given feed stream. The critical resource is the piece of equipment or other resource that limits or prevents further minimization of overall sludge processing times. This is reflected in the minimum hours required between the start of batches. However, the time required to process a batch of sludge from a given feed stream remains the same from one alternative to another. One general purpose of this study was to determine the quantity of specific resources that would be necessary to process all the sludge in a given timeframe.

5.2.1 2 Adjustment Tank Alternative

The 2 adjustment tank alternative is the simplest alternative considered. Simply stated, it consists of one piece of every kind of equipment found in the Sludge Treatment System Process Flow Diagram, H-1-81170, plus one additional adjustment tank. The time between the start of batches for this alternative range from 26 hours to 36 hours. For the feed streams with shorter dissolution times, KE1 and KW1, the critical resources are the adjustment tanks. For feed streams with longer dissolution times the critical resource is the dissolver.

5.2.2 3 Adjustment Tank Alternative

The 3 adjustment tank alternative adds an additional, or third, adjustment tank to the alternative described in the previous section. The time between the start of batches for this alternative range from 21 to 36 hours. The only feed streams where the time between batches was shortened by adding a third adjustment tank were KE1 and KW1, the ones where the adjustment tank was identified as the critical resource. However, since KE1 accounts for approximately 60% of the required processing days, the total sludge processing time would be reduced by more than 10% by adding a third adjustment tank. The supporting data for this can be found in Table 5-3.

Table 5-3 – Processing Days Including Scheduled Cleanings

Not Adjusted for Availability			
Stream	2 Adjustment Tanks Alternative	3 Adjustment Tanks Alternative	3 Adj. Tanks and 2 Dissolvers Alternative
KE1	193.8	157.5	140.0
KE2	39.3	39.0	26.9
KW1	16.6	14.7	13.9
KW2	19.5	19.5	13.3
KW3	32.8	32.3	23.7
Total Days	302.0	263.0	217.8

5.2.3 3 Adjustment Tank and 2 Dissolver Alternative

The final analyzed alternative adds a second dissolver to the 3 adjustment tank alternative. The time between the start of batches for this alternative range from 17 to 19 hours, with all feed streams having a corresponding drop in the number of days required to process. The total sludge processing time would be reduced by more than 17% by adding a second dissolver to the 3 adjustment tank alternative (See Table 5-3).

5.3 Alternatives Screened Out

The first alternative that was screened out and not analyzed in detail was one where there would be only 1 adjustment tank. This alternative would add approximately 24 hours to the minimum time allowed between the start of batches for the KE1 feed stream. It was determined that this alternative would greatly exceed the constraint of being able to process all the sludge in a 13-month timeframe. This is easily demonstrated by the fact that the 2 adjustment tank alternative requires an optimistic availability factor to meet the specified constraint.

The second alternative screened out was one where a fourth adjustment tank could be added to the 3 adjustment tank and 2 dissolver alternative. This alternative has the potential to shorten the time between batch starts by more than 2 or 3 hours for the 3 process feed streams (KE1, KE2, and KW3) which account for more than 87% of the processing days calculated for the 3 adjustment tank and 2 dissolver alternative. However, since the 3 adjustment tank and 2 dissolver alternative should be able to process the K Basin sludge within the specified timeframe assuming a reasonable availability factor. Based on this it was determined that adding a fourth adjustment tank at this time would give the appearance of minimizing sludge processing times as opposed to optimizing the processing times against resources. If the required availability factor is determined to be overly optimistic, or the estimate of sludge requiring processing increases, this alternative should be revisited.

No other alternatives have been considered at this time.

5.4 Data Collection and Generation

This section contains the data and summary information derived from the Microsoft Project models and the associated calculations described in section 5. It has been grouped by alternative where appropriate.

5.4.1 2 Adjustment Tank Alternative

Figure 5-4 contains the results of the Microsoft Project model for this alternative processing feed stream KE1. Figure 5-4 shows the summary steps for a four-batch progression with associated resource usage. For this alternative and feed stream, it can be seen that the adjustment tanks are the critical resource. Similar figures for this alternative processing the other feed streams can be found in Appendix B.

FIGURE 5-4

-2 Adjustment Tank Alternative Model for KE1

The data gathered from the five feed stream models for the 2 adjustment tank alternative is summarized in Table 5-4. Table 5-4 also includes the results of the resin processing calculation described earlier.

Table 5-4 – 2 Adjustment Tank Alternative Data

	Process Feed Stream				
	KE1	KE2	KW1	KW2	KW3
Hours between batch starts	26	32	26	36	28
Hours to get batch completely into adjustment tank	32	40	36	44	36
Hours until batch is out of adjustment tank	81	90	85	94	86
Hours beginning to end for one batch	93	103	98	107	99
Total Processing Hours Added by Resin Processing	365	17	0	0	21
Total Batches for feed stream	146.1	24.4	11.2	10.2	22.4

The information in Table 5-4 was then used to perform the calculations described in Section 5.1, and Microsoft Excel¹ was used to replicate the calculations. The resulting data can be found in Table 5-5.

Table 5-5 – Calculation Results for 2 Adj. Tanks Alternative

Process Feed Stream	Batch 10 start	Cleaning Start	Batch 11 Start	Batch 11 Start without cleaning	Time added per batch by cleaning	New Batch Start Equivalent	End Time of Final Batch	End Time of Final Batch Without Cleaning
KE1	234	290	314	285	2.9	28.9	4651.4	4230.6
KE2	288	328	352	320	3.2	35.2	943.7	868.8
KW1	234	270	294	260	3.4	29.4	397.9	363.2
KW2	324	368	392	360	3.2	39.2	467.6	438.2
KW3	252	288	312	280	3.2	31.2	787.7	719.2
All values are in hours								

¹Excel is a trademark of Microsoft Corporation.

The calculated data from Table 5-5 can then be converted into the final and most pertinent answer, resulting in Table 5-6. Table 5-6 contains the total processing days for the 2 Adjustment Tank Alternative with and without the assumed cleaning process. It is important to remember that these values have not been adjusted for overall plant availability.

Table 5-6 – Total Processing Days for 2 Adj. Tank Alt.

Process Feed Stream	Time to Process Stream <u>with</u> Cleaning (Days)	Time to Process Stream <u>without</u> Cleaning (Days)
KE1	193.8	176.3
KE2	39.3	36.2
KW1	16.6	15.1
KW2	19.5	18.3
KW3	32.8	30.0
Total	302.0	275.8

5.4.2 3 Adjustment Tank Alternative

Figure 5-5 contains the results of the Microsoft Project² model for this alternative processing feed stream KE1. Figure 5-5 shows the summary steps for a four-batch progression with associated resource usage. For this alternative and feed stream, it can be determined from the model that the dissolver is the critical resource. Similar figures for this alternative processing the other feed streams can be found in Appendix C.

²Project is a trademark of Microsoft Corporation.

The data gathered from the five feed stream models for the 3 Adjustment Tank alternative is summarized in Table 5-7. Table 5-7 also includes the results of the resin processing calculations.

Table 5-7 – 3 Adjustment Tank Alternative

	Process Feed Stream				
	KE1	KE2	KW1	KW2	KW3
Hours between batch starts	21	32	21	36	28
Hours to get batch completely into adjustment tank	32	40	36	44	36
Hours until batch is out of adjustment tank	81	90	85	94	86
Hours beginning to end for one batch	93	103	98	107	99
Total Processing Hours Added by Resin Processing	132	9	0	0	9
Total Batches for feed stream	146.1	24.4	11.2	10.2	22.4

The information in Table 5-7 was then used to perform the calculations described in Section 5.1, and Microsoft Excel was used to replicate the calculations. The resulting data can be found in Table 5-8.

Table 5-8 – Calculation Results for 3 Adj. Tanks Alternative

Process Feed Stream	Batch 10 start	Cleaning Start	Batch 11 Start	Batch 11 Start without cleaning	Time added per batch by cleaning	New Batch Start Equivalent	End Time of Final Batch	End Time of Final Batch Without Cleaning
KE1	189	230	254	219	3.5	24.5	3780.0	3272.1
KE2	288	328	352	320	3.2	35.2	935.7	860.8
KW1	189	225	249	210	3.9	24.9	352.0	312.2
KW2	324	368	392	360	3.2	39.2	467.6	438.2
KW3	252	288	312	280	3.2	31.2	775.7	707.2
All values are in hours								

The data in the final 2 columns of Table 5-8 were then converted into days to provide an easily understood basis for comparison with the other alternatives. This data is reported in Table 5-9 as the total processing days for the 3 Adjustment Tank Alternative with and

without the assumed cleaning process. It is important to remember that these values have not been adjusted for overall plant availability.

Table 5-9 – Total Processing Days for 3 Adj. Tank Alt.

Process Feed Stream	Time to Process Stream <u>with</u> Cleaning (Days)	Time to Process Stream <u>without</u> Cleaning (Days)
KE1	157.5	136.3
KE2	39.0	35.9
KW1	14.7	13.0
KW2	19.5	18.3
KW3	32.3	29.5
Total	263.0	232.9

5.4.3 3 Adjustment Tank and 2 Dissolver Alternative

Figure 5-6 contains the results of the Microsoft Project model for this alternative processing feed stream KE1. Figure 5-6 shows the summary steps for a four-batch progression with associated resource usage. For this alternative and feed stream, it can be determined from the model that the time between batch starts has been reduced to 17 hours, but the adjustment tanks are again the critical resource. Similar figures for this alternative processing the other feed streams can be found in Appendix D.

The data gathered from the five feed stream models for the 3 Adjustment Tank and 2 Dissolver alternative is summarized in Table 5-10. Table 5-10 also includes the results of the resin processing calculations for this alternative.

Table 5-10 – 3 Adjustment Tank and 2 Dissolver Alternative Data

	Process Feed Stream				
	KE1	KE2	KW1	KW2	KW3
Hours between batch starts	17	18	19	18	17
Hours to get batch completely into adjustment tank	32	40	36	44	36
Hours until batch is out of adjustment tank	81	90	85	94	86
Hours beginning to end for one batch	93	103	98	107	99
Total Processing Hours Added by Resin Processing	278	13	0	0	15
Total Batches for feed stream	146.1	24.4	11.2	10.2	22.4

The information in Table 5-10 was used to perform the calculations described in Section 5.1, and Microsoft Excel was used to replicate the calculations. The resulting data is in Table 5-11.

Table 5-11 – Calculation Results for 3 Adj. Tanks and 2 Dissolver Alternative

Process Feed Stream	Batch 10 start	Cleaning Start	Batch 11 Start	Batch 11 Start without cleaning	Time added per batch by cleaning	New Batch Start Equivalent	End Time of Final Batch	End Time of Final Batch Without Cleaning
KE1	153	201	225	189	3.6	20.6	3360.1	2837.7
KE2	162	202	226	180	4.6	22.6	644.8	537.2
KW1	171	207	231	190	4.1	23.1	333.6	291.8
KW2	162	206	230	180	5	23	318.6	272.6
KW3	153	189	213	170	4.3	21.3	569.8	477.8
All values are in hours								

The data in the final 2 columns of Table 5-11 were then converted into days to provide an easily understood basis for comparison with the other alternatives. This data is reported in Table 5-12 as the total processing days for the 3 Adjustment Tank and 2 Dissolver Alternative with and without the assumed cleaning process. It is important to remember that these values have not been adjusted for overall plant availability as discussed in Section 5.1.3 and displayed in Figures 1-1 and 1-2.

Table 5-12 – Total Processing Days for 3 Adj. Tank and 2 Dissolver Alternative

Process Feed Stream	Time to Process Stream <u>with</u> Cleaning (Days)	Time to Process Stream <u>without</u> Cleaning (Days)
KE1	140.0	118.2
KE2	26.9	22.4
KW1	13.9	12.2
KW2	13.3	11.4
KW3	23.7	19.9
Total	217.8	184.0

5.5 Evaluation and Analysis of Alternatives against Decision Criteria

Each alternative has been given a grade for each of the three criteria, based on the discussion in Section 4.0 and the particular raw data the criteria is measured against (See Table 5-13). The raw values for the first criteria can be found in Table 5-3. Based on the scale discussed in Section 4.0, the following calculation can then be performed for each alternative to determine the score for the first criteria:

$$(350 \text{ days} - \text{unadjusted total processing days}) * (.05 \text{ points/day}) = \text{Score}$$

Figure 5-1 can be used to estimate the minimum availability factor needed to process all sludge in 350 days, or it can be calculated by dividing the unadjusted number of days by 350 days. This is then the raw value for the second criteria. Based on the range discussed in Section 4.0, the following calculation is then performed:

$$(90\% - \text{availability factor}) * (.25 \text{ points} / \%) = \text{Score}$$

As stated in section 4.0 the third criteria is much more subjective and requires more discussion since there is not any hard data to use as raw values. The first assumption made in determining the grades for the third criteria is that adding an additional dissolver will cost much more than adding an additional adjustment tank. An additional dissolver

also increases the operational complexity much more than an additional adjustment tank would. Based on the factors discussed above, the following scale will be used to grade alternatives at this time:

Baseline (one of everything) = 10 points
 Additional Adjustment Tank = -1.5 points
 Additional Dissolvers = -3.0 points

This scale may need changes if additional alternatives are analyzed in the future. The grades calculated using this scale can be found in Table 5-13.

The weighted point total is then calculated by multiplying each score by the weighting factor for that criteria.

Table 5-13 -- Time Diagram Decision Criteria Analysis Results

Decision Criteria	Criteria Weighting	Alt. 1	Alt. 2	Alt. 3
The amount of time the analyzed alternative takes to complete processing of all sludge. The measured value will be the one that includes scheduled cleanings, and is unadjusted for plant availability.	50%	2.4 points (302.0 days)	4.4 points (263.0 days)	6.6 points (217.8 days)
The availability estimate required for the analyzed alternative to achieve compliance with criteria 1 (Process all sludge in less than 350 days).	30%	.9 points (86.3%)	3.7 points (75.1%)	6.9 points (62.2%)
The amount of duplicate equipment required.	20%	8.5 points	7 points	4 points
Weighted Point Total		3.17	4.71	6.17

Alternative 1 – 2 Adjustment Tank Alternative
 Alternative 2 – 3 Adjustment Tank Alternative
 Alternative 3 – 3 Adjustment Tank and 2 Dissolver Alternative

Alternative 3, the 3 Adjustment Tank and 2 Dissolver Alternative receives the highest score using the discussed point scales and weighting criteria. It is important to note that if priorities change, the criteria weights may change. Or additional alternatives or technical review might change the defined point scales. In either case, the weighted point total could see significant changes.

5.6 Programmatic Risk Analysis

When risk is considered, it is often a given that when enabling assumptions are made to allow definition of a process, programmatic risks are inherent with those assumptions. In the case of this time diagram study, the whole thing is based on a set of assumptions. For that reason, only a few of the most significant risks will be discussed.

5.6.1 Sampling Turnaround and Adjustment Tank Risks

The most significant assumption, in terms of time, is the assumption that overall sampling turnaround times will be 48 hours. This assumption on sampling could have great swings to both the good and bad. It is possible that if the right infrastructure were put in place, the turnaround time could be significantly reduced, maybe by more than half. However, it is much more likely that many times during the processing life of the proposed alternatives the sampling turnaround times will extend well beyond the 2 day period which has been assumed. Each delay in sampling turnaround, will be almost an hour for hour delay for the whole feed stream being processed. This will be especially critical when the adjustment tanks are the critical resource. Any discussion on reducing the number of required adjustment tanks should be evaluated against this risk, and cost effective improvements which could shorten the sampling turnaround time should be considered.

5.6.2 Process Feed and Product Transportation Risks

Another significant area of risk is in the transporting of both process feed and process products. At this time, neither multiple lag storage tanks for process feed, nor multiple storage tanks for neutralized product have been modeled. If the sludge removal and transport systems cannot supply sludge on demand, processing would be delayed whenever those systems failed to supply sludge. A related problem is that any increase in the number of lag storage tanks will require an increase in facility size, which may not have been accounted for. A similar and associated risk is that the time diagram models have only one neutralization tank that transfers directly into the transport system going to TWRS. If the transport system to TWRS is unable to keep up with demand, the process will face delays. All of these issues need to be integrated with the planned transportation studies.

5.6.3 Sludge Volume Risks

If the volume and associated mass of sludge that requires processing is greater than the mean value used in the process flow sheets, none of the alternatives might support meeting the TPA constraint of retrieving and processing all K Basin sludge in 13 months. To truly put the project at risk, the increase would probably have to be greater than 10 percent, and maybe closer to 20 percent. From a programmatic standpoint, the 3 Adjustment Tank and 2 Dissolver alternative that received the highest weighted score would also withstand an increase in sludge volume the best.

5.6.4 Conditioned Solids Settling Risks

A significant risk is being introduced to the overall process by accumulating 50+ m3 of settled solids slurry in one tank, allowing the solids to settle for the purpose of decanting excess water, and then assuming the remaining slurry can be homogenized. Significant changes to grouting portion of the process flowsheet might be experienced if the settled

solids can't readily be resuspended. The upside however, is that grouting activities may not have to be completed within the TPA mandated timeframe. If this is the case, the assumed risk value is greatly reduced because of reduced consequences.

5.6.5 Other Risks

There are a number of other less significant risks inherent in the assumptions made for this time diagram study. The first one is the risk that dissolution times will increase causing delays in processing. This risk is not particularly significant for an alternative with 2 dissolvers because the dissolver is the critical resource for only one feed stream, KW2. The dissolution time for KE1 for example, would have to more than triple before its dissolution time would begin to delay the process. If an alternative with one dissolver was chosen, the consequence of this risk would increase. The 3 Adjustment Tank alternative for example, has the dissolver as the critical resource for all 5 feed streams. Therefore, there would be a one for one increase between batch processing times and dissolution times.

The second risk is the potential for delays caused by greater flushing times for the centrifuge. The only time the centrifuge is the critical resource is when process feed stream KW1 is being processed by the 3 Adjustment Tank and 2 Dissolver alternative (the preferred alternative from section 5.5). However, for this same alternative, it would take an increase of more than 1 hour per flushing cycle or 3 hours per batch to effect the overall processing times of feed stream KE1. The other 3 feed streams would be unaffected by these changes.

The third risk comes from the amount of time assumed for the change out of a cartridge filter. It has been assumed that this process can take place in 12 hours (See Appendix A). Because the cartridge filter is in use for less than 1 hour per batch, a window of 16-35 hours is available for the change out process, depending on the feed stream and alternative being considered. If changes cause the typical change out time to go beyond the available window, a corresponding delay will take place once every four batches.

The fourth risk to be discussed also involves the cartridge filters. This time diagram study has assumed that the process for grouting cartridge filters can happen concurrently with the analyzed processes. This means the filters can either be safely stored until the end, then grouted at the same time the conditioned solids are being grouted, or the filters can be grouted in smaller groups while sludge is being processed. Either way, it has been assumed that the process of grouting cartridge filters will have no impact on the overall sludge processing times, and therefore the grouting of cartridge filters has not been analyzed. If some unforeseen restrictions eliminated the option of grouting cartridge filters while sludge is being processed, and a new interpretation of the TPA constraint required the grouting of cartridge filters be finished within the 13-month processing window, a 15-30 day addition to processing times could be realized. However, it is assumed that the likelihood of either event is very small.

The fifth risk concerns the total mass of Uranium inside the facility and potentially affects any of the alternatives. If a mass limit for total Uranium allowed inside the facility at one time is imposed, it could restrict the optimization of batch start times. The masses of Uranium used in Table 5-14 can be found in Westra (1998). The total mass of Uranium in 6 batches can be compared to the minimum safe mass in a UO₂ solution of 875 kg Uranium enriched up to 1.25% ²³⁵U as found in HNF-SD-SNF-CSE-009, Revision 1. While not strictly a criticality risk, there is a risk that mass limits may be imposed based on the criticality numbers. From Table 5-14 it can be seen that a significant mass of Uranium could be in the facility at one time when processing streams KE2, KW1, and KW3. This issue may require further study at a future time when the project is better defined.

Table 5-14 – Total Mass of Uranium in Facility

	Feed Streams				
	KE1	KE2	KW1	KW2	KW3
Maximum number of batches in the facility at one time under normal operating conditions (in all cases the lag storage tank is empty or almost empty)	5	6	5	6	6
Total mass Uranium per "160 kg of solids" batch (kg)	17.9	115.4	7.8	143.6	98.5
Total mass Uranium in 6 batches (kg)	107.4	692.4	46.8	861.6	591.0

The final risk discussed in this section deals with the commingling of multiple batch parts and products in the Resin Buffer Tank and the Solids Reception Tank. If events take place that preclude the project from collecting many batches worth of either the elutriation column light phase in the Resin Buffer Tank or the conditioned solids from the centrifuge in the Solids Reception Tank, the overall processing times could be significantly lengthened for the analyzed alternatives. However, it is assumed that the likelihood of either event is very small.

5.7 Sensitivity Analysis

The purpose of this section is to identify and discuss the significant sensitivity issues of each alternative. If a reasonable change to any assumption will cause a noticeable increase in processing time, that should be discussed here. It is also apparent that the most significant sensitivities will be those having an immediate effect on the processing of feed stream KE1 since it typically comprises more than 60% of the required processing days. It should also be noted that the deletion of processing steps, for example the removal of the resin separation step, can only decrease operating times when they affect a critical resource. Removing a processing step may shorten the total processing time for a single batch, but will only shorten the time between batch starts when the deleted step affects a critical resource.

5.7.1 Sensitivities of 2 Adjustment Tank Alternative

For feed streams KE1 and KW1 the adjustment tanks are the critical resources. Any increase in sampling turnaround time would be a one for one increase in total processing times for over 70% of the batches. It would take an increase of over 4 hours to affect any of the other feed streams. It is worth noting that a decrease in adjustment tank usage (i.e., sampling turnaround times) of up to 4 hours would decrease the time between batch starts for KE1 on a one to one basis. This could mean a decrease of up to 12% in total unadjusted processing days.

For feed streams KE2, KW2 and KW3 the dissolver is the critical resource. Any increases in dissolution times would be a one for one increase in total processing times for over 25% of the batches. It would take a dissolution time increase of over 4 hours to affect either the KE1 or KW1 feed streams.

For this alternative, those are the only resources susceptible to reasonable changes in their assumptions. It would take an increase of over 5 hours in centrifuging time, or a decrease of 5 hours for the adjustment tanks and 1 hour for the dissolver, to make centrifuging time an issue for stream KW1. This kind of increase in centrifuging time is possible for feed stream KW1 because of the high solids content, but KW1 only consists of 11.2 batches per the flowsheet. It would require an increase of over 12 hours in centrifuging time to impact the other feed streams.

5.7.2 Sensitivities of 3 Adjustment Tank Alternative

The dissolver is the critical resource for all 5 process feed streams. Any increases in dissolution times will have a direct, one to one, and effect. Conversely, any decrease in dissolver usage of up to 4 hours for KE1 and KW1 (even greater for the other feed streams), would also cause a direct, one to one, and decrease in time between batch starts.

The only other reasonable change that would affect this alternative would be an increase in centrifuging times for KW1 of more than 3 hours per batch. However, since KW1 consists of only 11.2 batches per the flowsheet, it would have little effect on the overall processing times.

5.7.3 Sensitivities of 3 Adjustment Tank and 2 Dissolver Alternative

The times between batch starts, for this alternative, have all been reduced from previous alternatives. Because of this, the number of potential sensitivity issues has increased. However, the most significant issues still involve adjustment tank usage and centrifuge/clarified liquid tank usage.

The adjustment tanks are the critical resource for KE1, KE2, and KW3. An increase in sampling turnaround times or other adjustment tank usage times would have a direct impact on total processing times, especially since these 3 feed streams comprise over 85% of the required processing days. The increase would have to be greater than 4 hours

per batch to effect the processing times of KW1 and KW2. On the other hand, adjustment tank usage could be reduced by more than 4 hours per batch for KE1 before the centrifuge/clarified liquid tank combination would approach critical resource status. The KE2 and KW3 feed streams could have adjustment tank usage reduced by 4 hours per batch before the dissolver became the critical resource. There would be no benefit for KW1, whose critical resource is already the centrifuge/clarified liquid tank combination, or KW2, whose critical resource is the dissolver.

An increase or decrease in dissolution times would only have direct impact on the processing of feed stream KW2. The dissolution time would have to increase by more than 4 hours to effect the processing of feed stream KE2, and 6-12 hours for any of the other feed streams.

This alternative is slightly more sensitive to centrifuge/clarified liquid tank assumption changes. While this resource is the critical resource for feed stream KW1 only, it would only take an increase of 3-4 hours per batch in centrifuge usage to start increasing the total processing time of feed stream KE1.

Finally, because the time between batch starts range from 17-19 hours for all feed streams, the assumed cartridge filter change out times could have an effect if found to be much longer than modeled. If the assumed filter change out time was increased from 12 hours to something greater than 17 hours the total processing time would increase. The increase would be the difference between the batch start time and newly greater filter change out time, once every four batches. It would take a five-hour increase to make any difference and an approximately 10-hour increase to extend the total processing time by 10 days.

6.0 CONCLUSIONS

Tables 6-1 and 6-2 summarize the information discussed in previous sections. It is fairly evident that it will require at least 3 adjustment tanks and 2 dissolvers to provide a comfortable margin between required processing days and the TPA driven timeframe of 390 days. However, previous discussions also document the great affect things like dissolution time and sample turnaround time can have on these processing times. Further study might show the increased life-cycle cost of adding a second dissolver is great enough to make the increased schedule risks of having only one dissolver acceptable. But, given the current weighted criteria summarized in Table 6-3 and the emphasis on meeting the TPA schedule, it is recommended that 3 adjustment tanks and 2 dissolvers be the planning basis for a K Basin sludge chemical processing system.

Table 6-1 – Processing Days Including Scheduled Cleanings

Adjusted for 70% Availability			
Process Feed Stream	2 Adjustment Tanks Alternative	3 Adjustment Tanks Alternative	3 Adj. Tanks and 2 Dissolvers Alternative
KE1	276.9	225.0	200.0
KE2	56.2	55.7	38.4
KW1	23.7	21.0	19.9
KW2	27.8	27.8	19.0
KW3	46.9	46.2	33.9
Total Days	431.4	375.7	311.1

Table 6-2 – Processing Days Without Scheduled Cleanings

Adjusted for 60% Availability			
Process Feed Stream	2 Adjustment Tanks Alternative	3 Adjustment Tanks Alternative	3 Adj. Tanks and 2 Dissolvers Alternative
KE1	293.8	227.2	197.1
KE2	60.3	59.8	37.3
KW1	25.2	21.7	20.3
KW2	30.4	30.4	18.9
KW3	49.9	49.1	33.2
Total Days	459.7	388.2	306.7

Table 6-3 -- Time Diagram Analysis Summary Results

Decision Criteria	Criteria Weighting	Alt. 1	Alt. 2	Alt. 3
Total Processing Time	50%	2.4 points (302.0 days)	4.4 points (263.0 days)	6.6 points (217.8 days)
The availability estimate required to process sludge in less than 350 days	30%	.9 points (86.3%)	3.7 points (75.1%)	6.9 points (62.2%)
The amount of duplicate equipment required (cost and complexity)	20%	8.5 points	7 points	4 points
Weighted Point Total		3.17	4.71	6.17

Alternative 1 – 2 Adjustment Tank Alternative

Alternative 2 – 3 Adjustment Tank Alternative

Alternative 3 – 3 Adjustment Tank and 2 Dissolver Alternative

7.0 REFERENCES

- Klimper, S. C., *SNF Project Sludge Treatment System Process Flow Diagram*, H-1-91170, Revision 0, Numatec Hanford Corporation, dated August 3, 1998.
- Roblyer, S. P. and Nelson, J. V., *Calculation of 1.25% ^{235}U Enriched UO_2 Solution Safe Slab, Safe Cylinder Diameter, Minimum Safe Mass, and Ion Exchange Module for CVDF*, HNF-SD-SNF-CSER-009, Revision 1, Fluor Daniel Northwest, Inc., Richland Washington, dated December 29, 1998.
- Westra, A. G., Flament, T. A., and de Lamartinie, L., *K Basin Sludge Treatment Process Description*, HNF-2735, Revision 0, Numatec Hanford Corporation, Richland, Washington, dated August 28, 1998.

APPENDIX A

COMPLETE LIST OF TIME DIAGRAM ASSUMPTIONS

This appendix contains all the time related assumptions used to define the durations of the process steps found in the Microsoft Project time diagram models. The assumptions in Table A-1 were made in terms of time to complete a process step. Except where noted these times have been applied to all 5 streams with no difference being made for slightly different volumes.

Table A-1 – Time Diagram Process Step Assumptions (9 pages)

Process Step	Assumptions
Store Process Feed	
Configure Receiving Station	-Can be done in 30 minutes
Receive Sludge	-Full feed batch received in one shipment -Transferred in 1 hour -Feed available from Sludge Removal any time it is needed
Homogenize Feed	-Can be adequately mixed within 10 minutes of completing transfer
Feed Screening Process	-No process restrictions; All process feed sent to screen in 1 hour
Screen Process Feed	
Screen Feed	-Assume full batch is screened -All feed screened and large pieces flushed to interim holding tank in 1 hour
Run Flush Water	-No flow or operational restrictions
Store and homogenize screened particles in interim holding tank	-Will store until screening is complete -Assume screened particles consist of 95% of OIER and 10% of all other solids
Send Sludge to Sludge Buffer Tank	-No flow restrictions; Can be done as fast as feed is screened
Send Large Particles to Elutriation Column	-This will start after screening is complete and will take 1 hour
Elutriate Resins	
Start Elutriation Column	-Time required to establish regulated flow in column is minimal, can start while feed is being screened, and does not impact process
Operate Elutriation Column	-Elutriation column can accept all screened particles in 45 minutes -Elutriation column can finish separating light and heavy phases within 15 minutes of receiving last screened particles, and flow of elutriating fluid can be readily adjusted to compensate for the stoppage of feed flow -Total estimated operating time is 1 hour

Light Phase to Resin Buffer Tank	-No process restrictions; will happen for whatever duration the elutriation column is operating -100% of OIER which enters elutriation column will go to the Resin Buffer Tank
Heavy Phase to Resin Buffer Tank	-This will take 30 additional minutes to complete after elutriation column is shut down
Store Sludge	
Receive Sludge From Screening/Elutriation	-No process restrictions; Can be safely accumulated at whatever rate it is received from screening/elutriation
Homogenize Sludge	-Can finish this within 10 minutes of completing the transfers into the Sludge Buffer Tank
Transfer Sludge to Dissolver	-Restricted by Dissolver; will take 8 hours to transfer batch and empty the Sludge Buffer Tank
Store Resin	
Receive Light Phase from Elutriation Column	-No process restrictions; Can be safely accumulated at whatever rate it is received from screening/elutriation
Store Resins	-Will store up to 10 batches worth of light phase from the Elutriation Column for KE1 (this is approximately 108 kg of solids and 514 liters of slurry) before sending to the Leaching Tank -Will receive and store the light phase from all batches of KE2 (40.2 kg solids, 173 liters of slurry) before sending to the Leaching Tank -Will receive and store the light phase from all batches of KW1, KW2, and KW3 together before sending to the Leaching Tank (approximately 42 kg of solids)
Homogenize Resins	-This will take 15 minutes, or less
Transfer Resins to Leaching Tank	-This can be done in 30 minutes -Won't start until adequate amount of resins have been accumulated and the Leaching Tank is done being used to leach centrifuged dissolver products
Dissolve Sludge	
Receive Recycled Nitric Acid	-Less than 10 minutes will be allocated for this
Add Initial Reagents to Dissolver (300-500 liters)	-Will do this in 30 minutes
Start Agitator	-No process impacts
Heat Dissolver Contents	-Assume 2 hours for this
Receive Sludge From Sludge Buffer Tank	-This will be spread out over 8 hours for safety considerations

Complete Reaction (additional reaction time required to complete reaction after receiving all feed from the Sludge Buffer Tank; dependent on particle size and feed composition)	-KE1: 4 hours -KE2: 16 hours -KW1: 2 hours -KW2: 20 hours -KW3: 12 hours
Cool Dissolver Contents	-Approximately 2 hours will be necessary for adequate cooling
Transfer Dissolver Contents to Centrifuge	-Transfers will occur at 1m ³ /hr -A transfer will be paused for flushing/washing whenever 18 kg of solids have been accumulated in the centrifuge (e.g., there will be 2 intermittent flushings per batch for KE1 feed and each flushing will take 55 minutes based on centrifuge assumptions); therefore the total time to <u>transfer a batch and empty the dissolver</u> is as follows: KE1: 233 minutes (2 intermittent flushings) KE2: 147 minutes (0 intermittent flushings) KW1: 360 minutes (5 intermittent flushings) KW2: 147 minutes (0 intermittent flushings) KW3: 147 minutes (0 intermittent flushings)
Centrifuge Dissolver Slurry	
Start Centrifuge	-No process impacts
Clarify Dissolver Slurry	-Dissolver slurry will be received at 1m ³ /hr; based on this and flushing/washing assumptions below, the total time to <u>clarify a batch of dissolver slurry</u> is as follows: KE1: 283 minutes (3 flushings total) KE2: 197 minutes (1 flushing total) KW1: 410 minutes (6 flushings total) KW2: 197 minutes (1 flushing total) KW3: 197 minutes (1 flushing total)
Transfer Liquids to Clarified Liquid Tank	-No process restrictions; can occur at whatever rate the centrifuge produces clarified liquid
Stop Centrifuge When 18 kg of Solids Retained in Bowl or Done Clarifying Dissolver Slurry	-Clarification will be paused for flushing/washing whenever 18 kg of solids have been accumulated in the centrifuge (e.g., there will be 3 flushings total per batch for KE1 feed), minimal time (5 minutes) needed to stop centrifuge and prepare for flushing process
Flush Solids Cake with Water	-Can do this in 5 minutes (60 liters)
Homogenize Solids Cake and Water	-Can do this in 5 minutes
Recentrifuge Homogenized Slurry	-Can do this in 10 minutes
Transfer Wash Liquids to Clarified Liquid Tank	-No process restrictions
Flush Solids Cake With Water	-Can do this in 5 minutes (60 liters)
Homogenize Solids Cake and Water	-Can do this in 5 minutes

Transfer Centrifuged Dissolver Slurry to Leaching Tank	-Can do this in 5 minutes
Prepare Centrifuge for more feed	-Can do this in 5 minutes
Leach Rinsed Dissolver Solids	
Receive Centrifuged Dissolver Slurry	-No process restrictions; will take 5 minutes each time based on centrifuge assumption
Add Leaching Reagents	-Can do this in 30 minutes
Homogenize Slurry to Aid Leaching	-This will take 4 hours
Transfer Leached Dissolver Slurry to Centrifuge	<p>-Transfers will occur at 1m³/hr</p> <p>-A transfer will be paused for flushing/washing if 18 kg of solids have been accumulated in the centrifuge</p> <p>-The total time to <u>transfer a batch and empty the leaching tank</u> is as follows:</p> <p>KE1: 148 minutes (2 intermittent flushings)</p> <p>KE2: 13.2 minutes (0 intermittent flushings)</p> <p>KW1: 351 minutes (5 intermittent flushings)</p> <p>KW2: 15 minutes (0 intermittent flushings)</p> <p>KW3: 6.6 minutes (0 intermittent flushings)</p>
Centrifuge Leached Dissolver Slurry	
Start Centrifuge	-No process impacts
Clarify Leached Dissolver Slurry from Leaching Tank	<p>-Leached Dissolver slurry will be received at 1m³/hr; based on this and flushing/washing assumptions below, the total time to <u>clarify a batch of leached dissolver slurry</u> is as follows:</p> <p>KE1: 199 minutes (3 flushings total)</p> <p>KE2: 65 minutes (1 flushing total)</p> <p>KW1: 402 minutes (6 flushings total)</p> <p>KW2: 66 minutes (1 flushing total)</p> <p>KW3: 58 minutes (1 flushing total)</p>
Transfer Liquids to Clarified Liquid Tank	-No process restrictions; can occur at whatever rate the centrifuge produces clarified liquid
Stop Centrifuge when 18 kg of Solids Retained in Bowl or Done Clarifying Leached Dissolver Slurry	-Clarification will be paused for flushing/washing when 18 kg of solids have been accumulated in the centrifuge, minimal time (5 minutes) needed to stop centrifuge and prepare for flushing process
Flush Solids Cake with Water	-Can do this in 5 minutes (60 liters)
Homogenize Solids Cake and Water	-Can do this in 5 minutes
Recentrifuge Homogenized Slurry	-Can do this in 10 minutes
Transfer Wash Liquids to Clarified Liquid Tank	-No process restrictions
Flush Solids Cake With Water	-Can do this in 7 minutes (75 liters)

Homogenize Solids Cake and Water	-Can do this in 5 minutes
Transfer Leached/Flushed Dissolver Slurry to Solids Reception Tank	-Can do this in 5 minutes
Prepare Centrifuge for more feed	-Can do this in 5 minutes
Store Clarified Liquid	
Receive Clarified Dissolver Product Liquids From Centrifuge	-No process restrictions
Receive Dissolver Product Wash Liquids From Centrifuge	-No process restrictions
Receive Clarified Leached Dissolver Solids Liquid From Centrifuge	-No process restrictions
Receive Leached Dissolver Solids Wash Liquids From Centrifuge	-No process restrictions
Transfer Clarified Liquids to Cartridge Filter	-Time based on filter capacity of 150 liters/min. -Transfer time per batch is as follows: KE1: 28.4 minutes KE2: 21.3 minutes KW1: 36.1 minutes KW2: 21.7 minutes KW3: 20.0 minutes
Filter Clarified Liquid	
Process Clarified Liquid Through Cartridge	-Time based on filter capacity of 150 liters/min. -Transfer time per batch is as follows: KE1: 28.4 minutes KE2: 21.3 minutes KW1: 36.1 minutes KW2: 21.7 minutes KW3: 20.0 minutes
Transfer Filtered Liquid to Adjustment Tank	-No process restrictions
Rinse Cartridge Filter	-Assume this will take 30 minutes
Changeout Cartridge Filter	-Only occurs once every 4 batches -Assumed to take 12 hours
Send Used Cartridge Filter to Final Conditioning	-Transport causes no process restrictions -Adequate used filter storage at final conditioning
Adjust Filtered Liquid	
Receive and Store Filtered Liquid	-No process restrictions -Will take same time that it takes to process liquid through cartridge filter, plus the 30 minutes to receive the filter rinse water

Sample and wait for results	-Depending on infrastructure, information needed, and priorities this could take anywhere from 5 hours to 10 days -Will assume 2 days for initial time diagram
Add Adjustment Reagents	-Time varies greatly depending on amount of adjustments reagents needed; 0-1300 liters depending on the batch -Will assume 1 hour needed to transfer maximum amount; This assumes no safety considerations restrict flow rate -If a small amount of reagents are necessary, it is assumed a minimum of 15 minutes will be required for operational requirements -Following are the estimated times for each feed stream: KE1: 2 liters, 15 minutes KE2: 1,010 liters, 48 minutes KW1: 1 liter, 15 minutes KW2: 1,279 liters, 60 minutes KW3: 1,121 liters, 53 minutes
Homogenize Adjusted Liquid	-Assumed to take 15 minutes
Transfer Adjusted Liquid to Neutralization Tank	-Assume no flow restrictions and transfer can occur in 1 hour
Neutralize Adjusted Liquid	
Receive and Store Adjusted Liquid	-Assume no flow restrictions and transfer can occur in 1 hour
Add Neutralization Reagents	-Assume 1 hour, but could take longer due to safety considerations and exothermic reaction
Homogenize and Cool Neutralized Slurry	-Assume 2 hours
Sample Slurry to Confirm TWRS Acceptability	-Assume this step is not necessary
Transfer Neutralized Slurry to Transport System	-Assume 1.5 hours; Could be impacted by location of facility, and size and configuration of transfer system (1 - 6 trucks? Pipeline?)
Transfer Neutralized Slurry to TWRS	
Receive and Load Neutralized Slurry	-Transport system drives this, assume 1.5 hours for now
Transport Slurry to Tank Farms	-Assume round trip by tanker truck would take 8 hours; this includes any steps necessary to ensure truck is back at the facility and ready for reuse
Leach Resin Buffer Tank Contents	
Receive Resin Slurry from Resin Buffer Tank	-Assume this can be done in 30 minutes -Resins will only be leached when a sufficient mass of solids has been collected in the Resin Buffer Tank; Assume once every 10 batches for KE1, one time total for KE2, and one time total for all of KW1, KW2, and KW3

Add Leaching Reagents	-Can do this in 30 minutes
Homogenize Resin Slurry to Aid Leaching	-Assume this will take 4 hours
Transfer Leached Resin Slurry to Centrifuge	-Transfers will occur at 1m ³ /hr -A transfer will be paused for flushing/washing if 18 kg of solids have been accumulated in the centrifuge
Centrifuge Leached Resin Slurry	
Start Centrifuge	-No process impacts
Clarify Leached Resin Slurry from Leaching Tank	-Feed will be received at 1m ³ /hr
Transfer Liquids to Clarified Liquid Tank	-No process restrictions; can occur at whatever rate the centrifuge produces clarified liquid
Stop Centrifuge When 18 kg of Solids Retained in the Bowl or Done Clarifying the Leached Resin Slurry	-Clarification will be paused for flushing/washing when 18 kg of solids have been accumulated in the centrifuge or if all feed has been clarified, minimal time (5 minutes) needed to stop centrifuge and prepare for flushing process
Flush Solids Cake with Water	-Can do this in 5 minutes
Homogenize Solids Cake and Water	-Can do this in 5 minutes
Recentrifuge Homogenized Slurry	-Can do this in 10 minutes
Transfer Liquids to Clarified Liquid Tank	-No process restrictions
Flush Solids Cake With Water	-Can do this in 7 minutes
Homogenize Solids Cake and Water	-Can do this in 5 minutes
Transfer Leached/Flushed Resin Slurry to Solids Reception Tank	-Can do this in 5 minutes
Prepare Centrifuge for more feed	-Can do this in 5 minutes
Grout Treated Solids	
STEPS TO TREAT EXCESS LIQUID	
Receive Leached/Flushed Dissolver Slurry from Centrifuge	-Assume the following: KE1: 3 times per batch KE2: 1 time per batch KW1: 6 times per batch KW2: 1 time per batch KW3: 1 time per batch -Assume 20 minutes each time

Receive Leached/Flushed Resin Slurry from Centrifuge	-Assume 6 times each time KE1 resin slurry is leached (once every 10 batches), 3 times for KE2 resin slurry, and 3 times for all KW resin slurry -Assume 20 minutes each time
Settle Solids in Solids Reception Tank	-Assume this requires 5 days after end of last addition
Decant Excess Liquid and Transfer to Clarified Liquid Tank	-This will require multiple transfers dependent on Clarified Liquid Tank size; This exercise will assume 6 equal transfers of 5,527 liter batches -Assume each transfer takes 1 hour
Filter Excess Liquid	-Assume 38 minutes per batch
Adjust Filtered Excess Liquid	-Assume 48 hours to sample and get results -Assume no time for adding adjustment reagents since mass balance indicates less than 1 liter per batch would be required -Assume transfer to Neutralization Tank tanks 1 hour
Neutralize Excess Liquid	-Assume neutralization reagents can be added in 15 minutes -Assume 30 minutes to homogenize and cool -Assume 1.5 hours to transfer neutralized slurry to transport system
Transport Neutralized Slurry to TWRS	-Assume 1.5 hours to load transport -Assume 8 hours to make round trip to TWRS
STEPS TO GROUT SLURRY	
Homogenize Remaining Slurry	-Assume this takes 8 hours -Assume this will be done after decantation is complete
Sample Slurry and Wait For Results	-Assume this takes 2 days -Assume this will be done after homogenization is complete
Restart Homogenization System	-Mixing system will be stopped for sampling, but restarted and continuously run after that while each grout liner is filled; The mixing systems will be run for at least 2 hours before transferring slurry to a liner
Transfer Slurry to Grout Liner	-Assume this transfer will happen in 1 hour
Add Grout Formers	-Assume this will happen in 1 hour
Cure Grout Product in Liner	-Assume 2 days for this
Cap and Seal Grout Liner	-Assume 4 hours
Load Grout Liner on Transport	-Assume 4 hours
Transfer Grout to ERDF	-Assume 8 hours for round trip
Grout Used Cartridge Filters	
Receive Used Cartridge Filters	-Assume 1 filter every 4 batches
Load Cartridge Filters in Drums	-Assume 1 filter per drum, loaded when received; assume this takes 8 hours

Store Filters in Drums	-Assume this can be done until all used filters have been collected; storage restrictions might require that filters in drums be grouted before all have been collected -Assume 49-70 drums/filters will need stored; PFD indicates a minimum of 48.4 filters will be used and the actual number depends on when changeouts will be scheduled
Prepare Grouting Matrix	-Preparation time 4 hours
Grout Filters in Drums	-1 hour per 4 drum set -3 hours between sets to allow initial setting of grout (safer to move) and provide time to move filled drums, and position new set of non-filled drums
Cure Grout Product in Drums	-24 hours per 4 drum set -Assume as many sets as needed can be stored for curing
Cap and Seal Drums	-2 hours per 4 drum set
Load Drums on Transport	-1 hour per 4 drum set
Transfer Drums to ERDF or WIPP	-Assume ERDF is acceptable disposal destination -Assume 8 hours per 4 drum set for complete round trip including any unloading and redeployment steps

APPENDIX B

SUPPORT INFORMATION AND CALCULATION RESULTS FOR THE 2 ADJUSTMENT TANKS ALTERNATIVE

This appendix contains the complete set of Microsoft Project produced summary time diagrams for the 2 Adjustment Tanks Alternative. The summary time diagrams contain the summary process steps for 4 consecutive batches. They do not include the processing of elutriation column light phases, cleaning/maintenance activities, or the grouting processes. Following each summary time diagram is a listing of all process steps for one batch of the same feed stream, their duration and related steps (predecessors), and the particular resources being used during those steps. The summary time diagrams are figures B-1, B-3, B-5, B-7, and B-9. The detailed process step listings are figures B-2, B-4, B-6, B-8, and B-10.

The information obtained from the Microsoft Project models is then summarized in Figure B-11. Figure B-11 contains the Microsoft Excel spreadsheet used for the 2 Adjustment Tanks Alternative calculations. The top part shows the information gathered from the models, and the middle and bottom parts are the result of the calculations described in Section 5.1 and replicated in Excel.

Figure B-2 -- KE1 Process Steps for 2 Adjustment Tank Alternative

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
1	KE1 FEED STREAM	0 hrs				
2	Multiple batch example with the following provisions:	0 hrs				12:00 AM
3	2 Adjustment Tanks	0 hrs				12:00 AM
4	26 hours between batch starts	0 hrs				12:00 AM
5						
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank		
7	Configure Receiving Station	0.5 hrs				
8	Receive Sludge	1 hr	7			
9	Homogenize Feed	0.17 hrs	8			
10	Feed Screening Process	1 hr	9			
11						
12	Screen Process Feed (Batch 1)	2 hrs		Screening System		
13	Screen Feed	1 hr	10SS			
14	Run Flush Water As Needed	1 hr	10SS			
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank		
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS			
17	Send Screened Particles to Elutriation Column	1 hr	15FF			
18						
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column		
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs			
21	Operate Elutriation Column	1 hr	17SS			
22	Light Phase to Resin Buffer Tank	1 hr	21SS			
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS			
24						
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank		
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF			
27	Homogenize Sludge	0.17 hrs	26			
28	Transfer Sludge to Dissolver	8 hrs	27			
29						
30	Dissolve Sludge (Batch 1)	16.67 hrs		Dissolver		
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs			
32	Add Initial Reagents to Dissolver	0.5 hrs	31			
33	Start Agitator	0.08 hrs	32FS-0.08 hrs			
34	Heat Dissolver Contents	2 hrs	33			
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS			
36	Complete Reaction	4 hrs	35			
37	Cool Dissolver Contents	2 hrs	36			
38						
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	3.88 hrs		Dissolver		
40	Transfer 18 kg solids to Centrifuge (885 liters)	0.88 hrs	37			
41	Transfer 18 kg solids to Centrifuge (885 liters)	0.88 hrs	56			
42	Transfer Remaining Volume to Centrifuge (610 liters)	0.62 hrs	67			
43						
44	Centrifuge Dissolver Products (Batch 1)	4.71 hrs		Centrifuge		

Figure B-2 -- KE1 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
45	Start Centrifuge	0.08 hrs	40SS-0.08 hrs			
46	Clarify Feed From Dissolver	0.88 hrs	40SS			
47	Transfer Liquids to Clarified Liquid Tank	0.88 hrs	46SS			
48	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	46			
49	Flush Solids Cake With Water (60 liters)	0.08 hrs	48			
50	Homogenize Solids Cake and Water	0.08 hrs	49			
51	Recentrifuge Homogenized Slurry	0.17 hrs	50			
52	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	51SS			
53	Flush Solids Cake With Water (60 liters)	0.08 hrs	52			
54	Homogenize Solids Cake and Water	0.08 hrs	53			
55	Transfer Solution to Leaching Tank	0.08 hrs	54			
56	Prepare Centrifuge for more feed	0.08 hrs	55			
57	Clarify Feed From Dissolver	0.88 hrs	41SS			
58	Transfer Liquids to Clarified Liquid Tank	0.88 hrs	57SS			
59	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	57			
60	Flush Solids Cake With Water (60 liters)	0.08 hrs	59			
61	Homogenize Solids Cake and Water	0.08 hrs	60			
62	Recentrifuge Homogenized Slurry	0.17 hrs	61			
63	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	62SS			
64	Flush Solids Cake With Water (60 liters)	0.08 hrs	63			
65	Homogenize Solids Cake and Water	0.08 hrs	64			
66	Transfer Solution to Leaching Tank	0.08 hrs	65			
67	Prepare Centrifuge for more feed	0.08 hrs	66			
68	Clarify Feed From Dissolver	0.62 hrs	42SS			
69	Transfer Liquids to Clarified Liquid Tank	0.62 hrs	68SS			
70	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	68			
71	Flush Solids Cake With Water (60 liters)	0.08 hrs	70			
72	Homogenize Solids Cake and Water	0.08 hrs	71			
73	Recentrifuge Homogenized Slurry	0.17 hrs	72			
74	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	73SS			
75	Flush Solids Cake With Water (60 liters)	0.08 hrs	74			
76	Homogenize Solids Cake and Water	0.08 hrs	75			
77	Transfer Solution to Leaching Tank	0.08 hrs	76			
78	Prepare Centrifuge for more feed	0.08 hrs	77			
79						
80	Leach Rinsed Dissolver Solids (Batch 1)	7.67 hrs		Leaching Tank		
81	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS			
82	Receive Centrifuged Dissolver Slurry	0.08 hrs	66SS			
83	Receive Centrifuged Dissolver Slurry	0.08 hrs	77SS			
84	Add Leaching Reagents	0.5 hrs	83			
85	Homogenize Slurry to Aid Leaching	4 hrs	84			
86						
87	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	2.46 hrs		Leaching Tank		
88	Transfer 18 kg solids to Centrifuge (361 liters)	0.37 hrs	85			

Figure B-2 -- KE1 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
89	Transfer 18 kg solids to Centrifuge (361 liters)	0.37 hrs	104			
90	Transfer Remaining Volume to Centrifuge (195 liters)	0.2 hrs	115			
91						
92	Centrifuge Leached Dissolver Slurry (Batch 1)	3.31 hrs		Centrifuge		
93	Start Centrifuge	0.08 hrs	88SS-0.08 hrs			
94	Clarify Feed From Leaching Tank	0.37 hrs	88SS			
95	Transfer Liquids to Clarified Liquid Tank	0.37 hrs	94SS			
96	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	94			
97	Flush Solids Cake With Water (60 liters)	0.08 hrs	96			
98	Homogenize Solids Cake and Water	0.08 hrs	97			
99	Recentrifuge Homogenized Slurry	0.17 hrs	98			
100	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	99SS			
101	Flush Solids Cake With Water (75 liters)	0.1 hrs	100			
102	Homogenize Solids Cake and Water	0.08 hrs	101			
103	Transfer Solution to Solids Reception Tank	0.08 hrs	102			
104	Prepare Centrifuge for more feed	0.08 hrs	103			
105	Clarify Feed From Leaching Tank	0.37 hrs	89SS			
106	Transfer Liquids to Clarified Liquid Tank	0.37 hrs	105SS			
107	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	105			
108	Flush Solids Cake With Water (60 liters)	0.08 hrs	107			
109	Homogenize Solids Cake and Water	0.08 hrs	108			
110	Recentrifuge Homogenized Slurry	0.17 hrs	109			
111	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	110SS			
112	Flush Solids Cake With Water (75 liters)	0.1 hrs	111			
113	Homogenize Solids Cake and Water	0.08 hrs	112			
114	Transfer Solution to Solids Reception Tank	0.08 hrs	113			
115	Prepare Centrifuge for more feed	0.08 hrs	114			
116	Clarify Feed From Leaching Tank	0.2 hrs	90SS			
117	Transfer Liquids to Clarified Liquid Tank	0.2 hrs	116SS			
118	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	116			
119	Flush Solids Cake With Water (60 liters)	0.08 hrs	118			
120	Homogenize Solids Cake and Water	0.08 hrs	119			
121	Recentrifuge Homogenized Slurry	0.17 hrs	120			
122	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	121SS			
123	Flush Solids Cake With Water (75 liters)	0.1 hrs	122			
124	Homogenize Solids Cake and Water	0.08 hrs	123			
125	Transfer Solution to Solids Reception Tank	0.08 hrs	124			
126	Prepare Centrifuge for more feed	0.08 hrs	125			
127						
128	Store Clarified Liquid (Batch 1)	12.56 hrs		Clarified Liquid Tank		
129	Receive Clarified Dissolver Liquids From Centrifuge	0.88 hrs	47SS			
130	Receive Wash Liquids From Centrifuge	0.17 hrs	52SS			
131	Receive Clarified Dissolver Liquids From Centrifuge	0.88 hrs	58SS			
132	Receive Wash Liquids From Centrifuge	0.17 hrs	63SS			

Figure B-2 -- KE1 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1		2
133	Receive Clarified Dissolver Liquids From Centrifuge	0.62 hrs	69SS				
134	Receive Wash Liquids From Centrifuge	0.17 hrs	74SS				
135	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.37 hrs	95SS				
136	Receive Wash Liquids From Centrifuge	0.17 hrs	100SS				
137	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.37 hrs	106SS				
138	Receive Wash Liquids From Centrifuge	0.17 hrs	111SS				
139	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.2 hrs	117SS				
140	Receive Wash Liquids From Centrifuge	0.17 hrs	122SS				
141	Transfer Clarified Liquid to Cartridge Filter	0.47 hrs	140FS+0.17 hrs				
142							
143	Filter Clarified Liquid (Batch 1)	1.07 hrs		Cartridge Filter			
144	Process Clarified Liquid Through Cartridge Filter	0.47 hrs	141SS				
145	Transfer Filtered Liquid to Adjustment Tank	0.47 hrs	144SS				
146	Rinse Cartridge Filter	0.5 hrs	145				
147	Changeout Cartridge Filter	0 hrs	146FS+0.1 hrs				
148	Send Used Cartridge Filter to Final Conditioning	0 hrs	147				
149							
150	Adjust Filtered Liquid (Batch 1)	50.47 hrs		Adjustment Tank 1			
151	Receive and Store Filtered Liquid	0.97 hrs	145SS				
152	Sample and Wait For Results	49 hrs	151				
153	Add Adjustment Reagents (~2 liters)	0.25 hrs	152				
154	Homogenize Adjusted Liquid	0.25 hrs	153				
155	Transfer Adjusted Liquid to Neutralization Tank	1 hr	154				
156							
157	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank			
158	Receive and Store Adjusted Liquid	1.06 hrs	155SS				
159	Add Neutralization Reagents	1 hr	158				
160	Homogenize and Cool Neutralized Slurry	2 hrs	159				
161	Sample Slurry to Confirm TWRS Acceptability	0 hrs	160				
162	Transfer Neutralized Slurry to Transport System	1.5 hrs	161				
163							
164	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport			
165	Receive and Load Neutralized Slurry	1.5 hrs	162SS				
166	Transport Slurry to Tank Farms	8 hrs	165				
167							
168	END BATCH 1	0 hrs					
169	This marks the end of batch 1	0 hrs	166				
170							
171							
172	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank			
173	Configure Receiving Station	0.5 hrs	7SS+26 hrs				
174	Receive Sludge	1 hr	173				
175	Homogenize Feed	0.17 hrs	174				
176	Feed Screening Process	1 hr	175

Figure B-4 -- KE2 Process Steps for 2 Adjustment Tank Alternative

ID	Task Name	Duration	Predecessors	Resource Names
1	KE2 FEED STREAM	0 hrs		
2	Multiple batch example with the following provisions:	0 hrs		
3	2 Adjustment Tanks	0 hrs		
4	32 hours between batch starts	0 hrs		
5				
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank
7	Configure Receiving Station	0.5 hrs		
8	Receive Sludge	1 hr	7	
9	Homogenize Feed	0.17 hrs	8	
10	Feed Screening Process	1 hr	9	
11				
12	Screen Process Feed (Batch 1)	2 hrs		Screening System
13	Screen Feed	1 hr	10SS	
14	Run Flush Water As Needed	1 hr	10SS	
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS	
17	Send Screened Particles to Elutriation Column	1 hr	15FF	
18				
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs	
21	Operate Elutriation Column	1 hr	17SS	
22	Light Phase to Resin Buffer Tank	1 hr	21SS	
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS	
24				
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF	
27	Homogenize Sludge	0.17 hrs	26	
28	Transfer Sludge to Dissolver	8 hrs	27	
29				
30	Dissolve Sludge (Batch 1)	28.67 hrs		Dissolver
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs	
32	Add Initial Reagents to Dissolver	0.5 hrs	31	
33	Start Agitator	0.08 hrs	32FS-0.08 hrs	
34	Heat Dissolver Contents	2 hrs	33	
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS	
36	Complete Reaction	16 hrs	35	
37	Cool Dissolver Contents	2 hrs	36	
38				
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.45 hrs		Dissolver

Figure B-4 -- KE2 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
40	Transfer 11.6 kg solids to Centrifuge (2451 liters)	2.45 hrs	37	
41				
42	Centrifuge Dissolver Products (Batch 1)	3.28 hrs		Centrifuge
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs	
44	Clarify Feed From Dissolver	2.45 hrs	40SS	
45	Transfer Liquids to Clarified Liquid Tank	2.45 hrs	44SS	
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44	
47	Flush Solids Cake With Water (60 liters)	0.08 hrs	46	
48	Homogenize Solids Cake and Water	0.08 hrs	47	
49	Recentrifuge Homogenized Slurry	0.17 hrs	48	
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS	
51	Flush Solids Cake With Water (60 liters)	0.08 hrs	50	
52	Homogenize Solids Cake and Water	0.08 hrs	51	
53	Transfer Solution to Leaching Tank	0.08 hrs	52	
54	Prepare Centrifuge for more feed	0.08 hrs	53	
55				
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS	
58	Add Leaching Reagents	0.5 hrs	57	
59	Homogenize Slurry to Aid Leaching	4 hrs	58	
60				
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.22 hrs		Leaching Tank
62	Transfer 10.9 kg solids to Centrifuge (218 liters)	0.22 hrs	59	
63				
64	Centrifuge Leached Dissolver Slurry (Batch 1)	1.07 hrs		Centrifuge
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs	
66	Clarify Feed From Leaching Tank	0.22 hrs	62SS	
67	Transfer Liquids to Clarified Liquid Tank	0.22 hrs	66SS	
68	Stop Centrifuge When Clarification Complete	0.08 hrs	66	
69	Flush Solids Cake With Water (60 liters)	0.08 hrs	68	
70	Homogenize Solids Cake and Water	0.08 hrs	69	
71	Recentrifuge Homogenized Slurry	0.17 hrs	70	
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS	
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72	
74	Homogenize Solids Cake and Water	0.08 hrs	73	
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74	
76	Prepare Centrifuge for more feed	0.08 hrs	75	
77				
78	Store Clarified Liquid (Batch 1)	8.78 hrs		Clarified Liquid Tank

Figure B-4 -- KE2 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
79	Receive Clarified Dissolver Liquids From Centrifuge	2.45 hrs	45SS	
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS	
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.22 hrs	67SS	
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS	
83	Transfer Clarified Liquid to Cartridge Filter	0.36 hrs	82FS+0.17 hrs	
84				
85	Filter Clarified Liquid (Batch 1)	0.96 hrs		Cartridge Filter
86	Process Clarified Liquid Through Cartridge Filter	0.36 hrs	83SS	
87	Transfer Filtered Liquid to Adjustment Tank	0.36 hrs	86SS	
88	Rinse Cartridge Filter	0.5 hrs	87	
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs	
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89	
91				
92	Adjust Filtered Liquid (Batch 1)	50.9 hrs		Adjustment Tank 1
93	Receive and Store Filtered Liquid	0.86 hrs	87SS	
94	Sample and Wait For Results	48 hrs	93	
95	Add Adjustment Reagents (~1010 liters)	0.79 hrs	94	
96	Homogenize Adjusted Liquid	0.25 hrs	95	
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96	
98				
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS	
101	Add Neutralization Reagents	1 hr	100	
102	Homogenize and Cool Neutralized Slurry	2 hrs	101	
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102	
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103	
105				
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS	
108	Transport Slurry to Tank Farms	8 hrs	107	
109				
110	END BATCH 1	0 hrs		
111	This marks the end of batch 1	0 hrs	108	
112				
113				
114	Store Process Feed (Batch 2)	2.87 hrs		Lag Storage Tank
115	Configure Receiving Station	0.5 hrs	7SS+32 hrs	
116	Receive Sludge	1 hr	115	
117	Homogenize Feed	0.77 hrs	116

Figure B-6 -- KW1 Process Steps for 2 Adjustment Tank Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1	2
1	KW1 FEED STREAM	0 hrs				
2	Multiple batch example with the following provisions:	0 hrs			12:00 AM	
3	2 Adjustment Tanks	0 hrs			12:00 AM	
4	26 hours between batch starts	0 hrs			12:00 AM	
5						
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank		
7	Configure Receiving Station	0.5 hrs				
8	Receive Sludge	1 hr	7			
9	Homogenize Feed	0.17 hrs	8			
10	Feed Screening Process	1 hr	9			
11						
12	Screen Process Feed (Batch 1)	2 hrs		Screening System		
13	Screen Feed	1 hr	10SS			
14	Run Flush Water As Needed	1 hr	10SS			
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank		
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS			
17	Send Screened Particles to Elutriation Column	1 hr	15FF			
18						
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column		
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs			
21	Operate Elutriation Column	1 hr	17SS			
22	Light Phase to Resin Buffer Tank	1 hr	21SS			
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS			
24						
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank		
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF			
27	Homogenize Sludge	0.17 hrs	26			
28	Transfer Sludge to Dissolver	8 hrs	27			
29						
30	Dissolve Sludge (Batch 1)	14.67 hrs		Dissolver		
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs			
32	Add Initial Reagents to Dissolver	0.5 hrs	31			
33	Start Agitator	0.08 hrs	32FS-0.08 hrs			
34	Heat Dissolver Contents	2 hrs	33			
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS			
36	Complete Reaction	2 hrs	35			
37	Cool Dissolver Contents	2 hrs	36			
38						
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	5.99 hrs		Dissolver		
40	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	37			
41	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	59			
42	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	70			
43	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	81			
44	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	92			

Figure B-6 -- KW1 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
45	Transfer Remaining Volume to Centrifuge (355 liters)	0.36 hrs	103			
46						
47	Centrifuge Dissolver Products (Batch 1)	6.82 hrs		Centrifuge		
48	Start Centrifuge	0.08 hrs	40SS-0.08 hrs			
49	Clarify Feed From Dissolver	0.38 hrs	40SS			
50	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	49SS			
51	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	49			
52	Flush Solids Cake With Water (60 liters)	0.08 hrs	51			
53	Homogenize Solids Cake and Water	0.08 hrs	52			
54	Recentrifuge Homogenized Slurry	0.17 hrs	53			
55	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	54SS			
56	Flush Solids Cake With Water (60 liters)	0.08 hrs	55			
57	Homogenize Solids Cake and Water	0.08 hrs	56			
58	Transfer Solution to Leaching Tank	0.08 hrs	57			
59	Prepare Centrifuge for more feed	0.08 hrs	58			
60	Clarify Feed From Dissolver	0.38 hrs	41SS			
61	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	60SS			
62	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	60			
63	Flush Solids Cake With Water (60 liters)	0.08 hrs	62			
64	Homogenize Solids Cake and Water	0.08 hrs	63			
65	Recentrifuge Homogenized Slurry	0.17 hrs	64			
66	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	65SS			
67	Flush Solids Cake With Water (60 liters)	0.08 hrs	66			
68	Homogenize Solids Cake and Water	0.08 hrs	67			
69	Transfer Solution to Leaching Tank	0.08 hrs	68			
70	Prepare Centrifuge for more feed	0.08 hrs	69			
71	Clarify Feed From Dissolver	0.38 hrs	42SS			
72	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	71SS			
73	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	71			
74	Flush Solids Cake With Water (60 liters)	0.08 hrs	73			
75	Homogenize Solids Cake and Water	0.08 hrs	74			
76	Recentrifuge Homogenized Slurry	0.17 hrs	75			
77	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	76SS			
78	Flush Solids Cake With Water (60 liters)	0.08 hrs	77			
79	Homogenize Solids Cake and Water	0.08 hrs	78			
80	Transfer Solution to Leaching Tank	0.08 hrs	79			
81	Prepare Centrifuge for more feed	0.08 hrs	80			
82	Clarify Feed From Dissolver	0.38 hrs	43SS			
83	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	82SS			
84	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	82			
85	Flush Solids Cake With Water (60 liters)	0.08 hrs	84			
86	Homogenize Solids Cake and Water	0.08 hrs	85			
87	Recentrifuge Homogenized Slurry	0.17 hrs	86			
88	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	87SS			

Figure B-6 -- KW1 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
89	Flush Solids Cake With Water (60 liters)	0.08 hrs	88			
90	Homogenize Solids Cake and Water	0.08 hrs	89			
91	Transfer Solution to Leaching Tank	0.08 hrs	90			
92	Prepare Centrifuge for more feed	0.09 hrs	91			
93	Clarify Feed From Dissolver	0.39 hrs	44SS			
94	Transfer Liquids to Clarified Liquid Tank	0.39 hrs	93SS			
95	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	93			
96	Flush Solids Cake With Water (60 liters)	0.08 hrs	95			
97	Homogenize Solids Cake and Water	0.08 hrs	96			
98	Recentrifuge Homogenized Slurry	0.17 hrs	97			
99	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	98SS			
100	Flush Solids Cake With Water (60 liters)	0.08 hrs	99			
101	Homogenize Solids Cake and Water	0.08 hrs	100			
102	Transfer Solution to Leaching Tank	0.08 hrs	101			
103	Prepare Centrifuge for more feed	0.08 hrs	102			
104	Clarify Feed From Dissolver	0.36 hrs	45SS			
105	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	104SS			
106	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	104			
107	Flush Solids Cake With Water (60 liters)	0.08 hrs	106			
108	Homogenize Solids Cake and Water	0.08 hrs	107			
109	Recentrifuge Homogenized Slurry	0.17 hrs	108			
110	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	109SS			
111	Flush Solids Cake With Water (60 liters)	0.08 hrs	110			
112	Homogenize Solids Cake and Water	0.08 hrs	111			
113	Transfer Solution to Leaching Tank	0.08 hrs	112			
114	Prepare Centrifuge for more feed	0.08 hrs	113			
115						
116	Leach Rinsed Dissolver Solids (Batch 1)	10.19 hrs		Leaching Tank		
117	Receive Centrifuged Dissolver Slurry	0.08 hrs	58SS			
118	Receive Centrifuged Dissolver Slurry	0.08 hrs	69SS			
119	Receive Centrifuged Dissolver Slurry	0.08 hrs	80SS			
120	Receive Centrifuged Dissolver Slurry	0.08 hrs	91SS			
121	Receive Centrifuged Dissolver Slurry	0.08 hrs	102SS			
122	Receive Centrifuged Dissolver Slurry	0.08 hrs	113SS			
123	Add Leaching Reagents	0.5 hrs	122			
124	Homogenize Slurry to Aid Leaching	4 hrs	123			
125						
126	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	5.85 hrs		Leaching Tank		
127	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	124			
128	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	146			
129	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	157			
130	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	168			
131	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	179			
132	Transfer Remaining Volume to Centrifuge (228 liters)	0.23 hrs	190			

Figure B-6 -- KW1 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
133						
134	Centrifuge Leached Dissolver Slurry (Batch 1)	6.69 hrs		Centrifuge		
135	Start Centrifuge	0.08 hrs	127SS-0.08 hrs			
136	Clarify Feed From Leaching Tank	0.36 hrs	127SS			
137	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	136SS			
138	Stop Centrifuge When 15 kg of solids retained	0.08 hrs	136			
139	Flush Solids Cake With Water (60 liters)	0.08 hrs	138			
140	Homogenize Solids Cake and Water	0.08 hrs	139			
141	Recentrifuge Homogenized Slurry	0.17 hrs	140			
142	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	141SS			
143	Flush Solids Cake With Water (75 liters)	0.1 hrs	142			
144	Homogenize Solids Cake and Water	0.08 hrs	143			
145	Transfer Solution to Solids Reception Tank	0.08 hrs	144			
146	Prepare Centrifuge for more feed	0.08 hrs	145			
147	Clarify Feed From Leaching Tank	0.36 hrs	128SS			
148	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	147SS			
149	Stop Centrifuge When 15 kg of solids retained	0.08 hrs	147			
150	Flush Solids Cake With Water (60 liters)	0.08 hrs	149			
151	Homogenize Solids Cake and Water	0.08 hrs	150			
152	Recentrifuge Homogenized Slurry	0.17 hrs	151			
153	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	152SS			
154	Flush Solids Cake With Water (75 liters)	0.1 hrs	153			
155	Homogenize Solids Cake and Water	0.08 hrs	154			
156	Transfer Solution to Solids Reception Tank	0.08 hrs	155			
157	Prepare Centrifuge for more feed	0.08 hrs	156			
158	Clarify Feed From Leaching Tank	0.36 hrs	129SS			
159	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	158SS			
160	Stop Centrifuge When 15 kg of solids retained	0.08 hrs	158			
161	Flush Solids Cake With Water (60 liters)	0.08 hrs	160			
162	Homogenize Solids Cake and Water	0.08 hrs	161			
163	Recentrifuge Homogenized Slurry	0.17 hrs	162			
164	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	163SS			
165	Flush Solids Cake With Water (75 liters)	0.1 hrs	164			
166	Homogenize Solids Cake and Water	0.08 hrs	165			
167	Transfer Solution to Solids Reception Tank	0.08 hrs	166			
168	Prepare Centrifuge for more feed	0.08 hrs	167			
169	Clarify Feed From Leaching Tank	0.36 hrs	130SS			
170	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	169SS			
171	Stop Centrifuge When 15 kg of solids retained	0.08 hrs	169			
172	Flush Solids Cake With Water (60 liters)	0.08 hrs	171			
173	Homogenize Solids Cake and Water	0.08 hrs	172			
174	Recentrifuge Homogenized Slurry	0.17 hrs	173			
175	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	174SS			
176	Flush Solids Cake With Water (75 liters)	0.1 hrs	175			

Figure B-6 -- KW1 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
177	Homogenize Solids Cake and Water	0.08 hrs	176			
178	Transfer Solution to Solids Reception Tank	0.08 hrs	177			
179	Prepare Centrifuge for more feed	0.08 hrs	178			
180	Clarify Feed From Leaching Tank	0.36 hrs	131SS			
181	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	180SS			
182	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	180			
183	Flush Solids Cake With Water (60 liters)	0.08 hrs	182			
184	Homogenize Solids Cake and Water	0.08 hrs	183			
185	Recentrifuge Homogenized Slurry	0.17 hrs	184			
186	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	185SS			
187	Flush Solids Cake With Water (75 liters)	0.1 hrs	186			
188	Homogenize Solids Cake and Water	0.08 hrs	187			
189	Transfer Solution to Solids Reception Tank	0.08 hrs	188			
190	Prepare Centrifuge for more feed	0.08 hrs	189			
191	Clarify Feed From Leaching Tank	0.23 hrs	132SS			
192	Transfer Liquids to Clarified Liquid Tank	0.23 hrs	191SS			
193	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	191			
194	Flush Solids Cake With Water (60 liters)	0.08 hrs	193			
195	Homogenize Solids Cake and Water	0.08 hrs	194			
196	Recentrifuge Homogenized Slurry	0.17 hrs	195			
197	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	196SS			
198	Flush Solids Cake With Water (75 liters)	0.1 hrs	197			
199	Homogenize Solids Cake and Water	0.08 hrs	198			
200	Transfer Solution to Solids Reception Tank	0.08 hrs	199			
201	Prepare Centrifuge for more feed	0.08 hrs	200			
202						
203	Store Clarified Liquid (Batch 1)	18.2 hrs		Clarified Liquid Tank		
204	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	50SS			
205	Receive Wash Liquids From Centrifuge	0.17 hrs	55SS			
206	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	61SS			
207	Receive Wash Liquids From Centrifuge	0.17 hrs	66SS			
208	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	72SS			
209	Receive Wash Liquids From Centrifuge	0.17 hrs	77SS			
210	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	83SS			
211	Receive Wash Liquids From Centrifuge	0.17 hrs	88SS			
212	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	94SS			
213	Receive Wash Liquids From Centrifuge	0.17 hrs	99SS			
214	Receive Clarified Dissolver Liquids From Centrifuge	0.36 hrs	105SS			
215	Receive Wash Liquids From Centrifuge	0.17 hrs	110SS			
216	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	137SS			
217	Receive Wash Liquids From Centrifuge	0.17 hrs	142SS			
218	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	148SS			
219	Receive Wash Liquids From Centrifuge	0.17 hrs	153SS			
220	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	159SS			

Figure B-6 -- KW1 Process Steps for 2 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
221	Receive Wash Liquids From Centrifuge	0.17 hrs	164SS			
222	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	170SS			
223	Receive Wash Liquids From Centrifuge	0.17 hrs	175SS			
224	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	181SS			
225	Receive Wash Liquids From Centrifuge	0.17 hrs	186SS			
226	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.23 hrs	192SS			
227	Receive Wash Liquids From Centrifuge	0.17 hrs	197SS			
228	Transfer Clarified Liquid to Cartridge Filter	0.61 hrs	227FS+0.17 hrs			
229						
230	Filter Clarified Liquid (Batch 1)	1.21 hrs		Cartridge Filter		
231	Process Clarified Liquid Through Cartridge Filter	0.61 hrs	228SS			
232	Transfer Filtered Liquid to Adjustment Tank	0.61 hrs	231SS			
233	Rinse Cartridge Filter	0.5 hrs	232			
234	Changeout Cartridge Filter	0 hrs	233FS+0.1 hrs			
235	Send Used Cartridge Filter to Final Conditioning	0 hrs	234			
236						
237	Adjust Filtered Liquid (Batch 1)	50.61 hrs		Adjustment Tank 1		
238	Receive and Store Filtered Liquid	1.11 hrs	232SS			
239	Sample and Wait For Results	48 hrs	238			
240	Add Adjustment Reagents (~1 liters)	0.25 hrs	239			
241	Homogenize Adjusted Liquid	0.25 hrs	240			
242	Transfer Adjusted Liquid to Neutralization Tank	1 hr	241			
243						
244	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank		
245	Receive and Store Adjusted Liquid	1.08 hrs	242SS			
246	Add Neutralization Reagents	1 hr	245			
247	Homogenize and Cool Neutralized Slurry	2 hrs	246			
248	Sample Slurry to Confirm TWRS Acceptability	0 hrs	247			
249	Transfer Neutralized Slurry to Transport System	1.5 hrs	248			
250						
251	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport		
252	Receive and Load Neutralized Slurry	1.5 hrs	249SS			
253	Transport Slurry to Tank Farms	8 hrs	252			
254						
255	END BATCH 1	0 hrs				
256	This marks the end of batch 1	0 hrs	253			
257						
258						
259	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank		
260	Configure Receiving Station	0.5 hrs	75S+26 hrs			
261	Receive Sludge	1 hr	260			
262	Homogenize Feed	0.17 hrs	261			
263	Feed Screening Process	1 hr	262			
264						

Figure B-8 -- KW2 Process Steps for 2 Adjustment Tanks Alternative

ID	Task Name	Duration	Predecessors	Resource Names
1	KW2 FEED STREAM	0 hrs		
2	Multiple batch example with the following provisions:	0 hrs		
3	2 Adjustment Tanks	0 hrs		
4	36 hours between batch starts	0 hrs		
5				
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank
7	Configure Receiving Station	0.5 hrs		
8	Receive Sludge	1 hr	7	
9	Homogenize Feed	0.17 hrs	8	
10	Feed Screening Process	1 hr	9	
11				
12	Screen Process Feed (Batch 1)	2 hrs		Screening System
13	Screen Feed	1 hr	10SS	
14	Run Flush Water As Needed	1 hr	10SS	
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS	
17	Send Screened Particles to Elutriation Column	1 hr	15FF	
18				
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs	
21	Operate Elutriation Column	1 hr	17SS	
22	Light Phase to Resin Buffer Tank	1 hr	21SS	
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS	
24				
25	Store Sludge (Batch 1)	10.87 hrs		Sludge Buffer Tank
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF	
27	Homogenize Sludge	0.17 hrs	26	
28	Transfer Sludge to Dissolver	8 hrs	27	
29				
30	Dissolve Sludge (Batch 1)	32.67 hrs		Dissolver
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs	
32	Add Initial Reagents to Dissolver	0.5 hrs	31	
33	Start Agitator	0.08 hrs	32FS-0.08 hrs	
34	Heat Dissolver Contents	2 hrs	33	
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS	
36	Complete Reaction	20 hrs	35	
37	Cool Dissolver Contents	2 hrs	36	
38				
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.44 hrs		Dissolver

Figure B-8 -- KW2 Process Steps for 2 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
40	Transfer 12.9 kg solids to Centrifuge (2441 liters)	2.44 hrs	37	
41				
42	Centrifuge Dissolver Products (Batch 1)	3.27 hrs		Centrifuge
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs	
44	Clarify Feed From Dissolver	2.44 hrs	40SS	
45	Transfer Liquids to Clarified Liquid Tank	2.44 hrs	44SS	
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44	
47	Flush Solids Cake With Water (60 liters)	0.08 hrs	46	
48	Homogenize Solids Cake and Water	0.08 hrs	47	
49	Recentrifuge Homogenized Slurry	0.17 hrs	48	
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS	
51	Flush Solids Cake With Water (60 liters)	0.08 hrs	50	
52	Homogenize Solids Cake and Water	0.08 hrs	51	
53	Transfer Solution to Leaching Tank	0.08 hrs	52	
54	Prepare Centrifuge for more feed	0.08 hrs	53	
55				
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS	
58	Add Leaching Reagents	0.5 hrs	57	
59	Homogenize Slurry to Aid Leaching	4 hrs	58	
60				
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.25 hrs		Leaching Tank
62	Transfer 12.2 kg solids to Centrifuge (245 liters)	0.25 hrs	59	
63				
64	Centrifuge Leached Dissolver Slurry (Batch 1)	1.1 hrs		Centrifuge
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs	
66	Clarify Feed From Leaching Tank	0.25 hrs	62SS	
67	Transfer Liquids to Clarified Liquid Tank	0.25 hrs	66SS	
68	Stop Centrifuge When Clarification Complete	0.08 hrs	66	
69	Flush Solids Cake With Water (60 liters)	0.08 hrs	68	
70	Homogenize Solids Cake and Water	0.08 hrs	69	
71	Recentrifuge Homogenized Slurry	0.17 hrs	70	
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS	
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72	
74	Homogenize Solids Cake and Water	0.08 hrs	73	
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74	
76	Prepare Centrifuge for more feed	0.08 hrs	75	
77				
78	Store Clarified Liquid (Batch 1)	8.81 hrs		Clarified Liquid Tank

Figure B-8 -- KW2 Process Steps for 2 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
79	Receive Clarified Dissolver Liquids From Centrifuge	2.44 hrs	45SS	
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS	
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.25 hrs	67SS	
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS	
83	Transfer Clarified Liquid to Cartridge Filter	0.37 hrs	82FS+0.17 hrs	
84				
85	Filter Clarified Liquid (Batch 1)	0.97 hrs		Cartridge Filter
86	Process Clarified Liquid Through Cartridge Filter	0.37 hrs	83SS	
87	Transfer Filtered Liquid to Adjustment Tank	0.37 hrs	86SS	
88	Rinse Cartridge Filter	0.5 hrs	87	
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs	
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89	
91				
92	Adjust Filtered Liquid (Batch 1)	51.12 hrs		Adjustment Tank 1
93	Receive and Store Filtered Liquid	0.87 hrs	87SS	
94	Sample and Wait For Results	48 hrs	93	
95	Add Adjustment Reagents (~1279 liters)	1 hr	94	
96	Homogenize Adjusted Liquid	0.25 hrs	95	
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96	
98				
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS	
101	Add Neutralization Reagents	1 hr	100	
102	Homogenize and Cool Neutralized Slurry	2 hrs	101	
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102	
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103	
105				
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS	
108	Transport Slurry to Tank Farms	8 hrs	107	
109				
110	END BATCH 1	0 hrs		
111	This marks the end of batch 1	0 hrs	108	
112				
113				
114	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank
115	Configure Receiving Station	0.5 hrs	7SS+36 hrs	
116	Receive Sludge	1 hr	115	
117	Homogenize Feed	0.17 hrs	116	

FIGURE B-9

Figure B-10 -- KW3 Process Steps for 2 Adjustment Tanks Alternative

ID	Task Name	Duration	Predecessors	Resource Names
1	KW3 FEED STREAM	0 hrs		
2	Multiple batch example with the following provisions:	0 hrs		
3	2 Adjustment Tanks	0 hrs		
4	28 hours between batch starts	0 hrs		
5				
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank
7	Configure Receiving Station	0.5 hrs		
8	Receive Sludge	1 hr	7	
9	Homogenize Feed	0.17 hrs	8	
10	Feed Screening Process	1 hr	9	
11				
12	Screen Process Feed (Batch 1)	2 hrs		Screening System
13	Screen Feed	1 hr	10SS	
14	Run Flush Water As Needed	1 hr	10SS	
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS	
17	Send Screened Particles to Elutriation Column	1 hr	15FF	
18				
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs	
21	Operate Elutriation Column	1 hr	17SS	
22	Light Phase to Resin Buffer Tank	1 hr	21SS	
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS	
24				
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF	
27	Homogenize Sludge	0.17 hrs	26	
28	Transfer Sludge to Dissolver	8 hrs	27	
29				
30	Dissolve Sludge (Batch 1)	24.67 hrs		Dissolver
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs	
32	Add Initial Reagents to Dissolver	0.5 hrs	31	
33	Start Agitator	0.08 hrs	32FS-0.08 hrs	
34	Heat Dissolver Contents	2 hrs	33	
35	Reclieve Sludge From Sludge Buffer Tank	8 hrs	28SS	
36	Complete Reaction	12 hrs	35	
37	Cool Dissolver Contents	2 hrs	36	
38				
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.44 hrs		Dissolver

Figure B-10 -- KW3 Process Steps for 2 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
40	Transfer 5.63 kg solids to Centrifuge (2438 liters)	2.44 hrs	37	
41				
42	Centrifuge Dissolver Products (Batch 1)	3.27 hrs		Centrifuge
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs	
44	Clarify Feed From Dissolver	2.44 hrs	40SS	
45	Transfer Liquids to Clarified Liquid Tank	2.44 hrs	44SS	
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44	
47	Flush Solids Cake With Water (60 liters)	0.08 hrs	46	
48	Homogenize Solids Cake and Water	0.08 hrs	47	
49	Recentrifuge Homogenized Slurry	0.17 hrs	48	
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS	
51	Flush Solids Cake With Water (60 liters)	0.08 hrs	50	
52	Homogenize Solids Cake and Water	0.08 hrs	51	
53	Transfer Solution to Leaching Tank	0.08 hrs	52	
54	Prepare Centrifuge for more feed	0.08 hrs	53	
55				
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS	
58	Add Leaching Reagents	0.5 hrs	57	
59	Homogenize Slurry to Aid Leaching	4 hrs	58	
60				
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.11 hrs		Leaching Tank
62	Transfer 5.3 kg solids to Centrifuge (107 liters)	0.11 hrs	59	
63				
64	Centrifuge Leached Dissolver Slurry (Batch 1)	0.96 hrs		Centrifuge
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs	
66	Clarify Feed From Leaching Tank	0.11 hrs	62SS	
67	Transfer Liquids to Clarified Liquid Tank	0.11 hrs	66SS	
68	Stop Centrifuge When Clarification Complete	0.08 hrs	66	
69	Flush Solids Cake With Water (60 liters)	0.08 hrs	68	
70	Homogenize Solids Cake and Water	0.08 hrs	69	
71	Recentrifuge Homogenized Slurry	0.17 hrs	70	
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS	
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72	
74	Homogenize Solids Cake and Water	0.08 hrs	73	
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74	
76	Prepare Centrifuge for more feed	0.08 hrs	75	
77				
78	Store Clarified Liquid (Batch 1)	8.63 hrs		Clarified Liquid Tank

Figure B-10 -- KW3 Process Steps for 2 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
79	Receive Clarified Dissolver Liquids From Centrifuge	2.44 hrs	45SS	
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS	
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.11 hrs	67SS	
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS	
83	Transfer Clarified Liquid to Cartridge Filter	0.33 hrs	82FS+0.17 hrs	
84				
85	Filter Clarified Liquid (Batch 1)	0.93 hrs		Cartridge Filter
86	Process Clarified Liquid Through Cartridge Filter	0.33 hrs	83SS	
87	Transfer Filtered Liquid to Adjustment Tank	0.33 hrs	86SS	
88	Rinse Cartridge Filter	0.5 hrs	87	
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs	
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89	
91				
92	Adjust Filtered Liquid (Batch 1)	50.96 hrs		Adjustment Tank 1
93	Receive and Store Filtered Liquid	0.83 hrs	87SS	
94	Sample and Wait For Results	48 hrs	93	
95	Add Adjustment Reagents (~1121 liters)	0.88 hrs	94	
96	Homogenize Adjusted Liquid	0.25 hrs	95	
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96	
98				
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS	
101	Add Neutralization Reagents	1 hr	100	
102	Homogenize and Cool Neutralized Slurry	2 hrs	101	
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102	
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103	
105				
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS	
108	Transport Slurry to Tank Farms	8 hrs	107	
109				
110	END BATCH 1	0 hrs		
111	This marks the end of batch 1	0 hrs	108	
112				
113				
114	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank
115	Configure Receiving Station	0.5 hrs	75SS+28 hrs	
116	Receive Sludge	1 hr	115	
117	Homogenize Feed	0.17 hrs	116	

Figure B-11– Excel Spreadsheet Calculation Display

2 Adjustment Tank Alternative

	KE1	KE2	KW1	KW2	KW3
Hours between batch starts	26	32	26	36	28
Hours to get batch completely into adjustment tank	32	40	36	44	36
Hours until batch is out of adjustment tank	81	90	85	94	86
Hours beginning to end for one batch	93	103	98	107	99
Total Processing Hours Added by Resin Processing	365	17	0	0	21
Total Batches for feed stream	146.1	24.4	11.2	10.2	22.4

The following numbers are derived starting with the equation $(n-1) \times (\text{time between batch starts}) = \text{start of batch } n$

All values are in hours, and assumes a cleaning every 10 batches unless otherwise stated.

	<u>Batch 10 start</u>	<u>Cleaning Start</u>	<u>Batch 11 Start</u>	<u>Batch 11 Start without cleaning</u>	<u>Time added per batch by cleaning</u>	<u>New Batch Start Equivalent</u>	<u>End Time of Final Batch</u>	<u>End Time of Final Batch Without Cleaning</u>
KE1	234	290	314	285	2.9	28.9	4651.4	4230.6
KE2	288	328	352	320	3.2	35.2	943.7	868.8
KW1	234	270	294	260	3.4	29.4	397.9	363.2
KW2	324	368	392	360	3.2	39.2	467.6	438.2
KW3	252	288	312	280	3.2	31.2	787.7	719.2
	<u>Time to Process Stream with Cleaning (Days)</u>	<u>Time to Process Stream without Cleaning (Days)</u>						
KE1	193.8	176.3						
KE2	39.3	36.2						
KW1	16.6	15.1						
KW2	19.5	18.3						
KW3	32.8	30.0						
Total	302.0	275.8						

APPENDIX C

SUPPORT INFORMATION AND CALCULATION RESULTS FOR THE 3 ADJUSTMENT TANKS ALTERNATIVE

This appendix contains the complete set of Microsoft Project produced summary time diagrams for the 3 Adjustment Tanks Alternative. The summary time diagrams contain the summary process steps for 4 consecutive batches. They do not include the processing of elutriation column light phases, cleaning/maintenance activities, or the grouting processes. Following each summary time diagram is a listing of all process steps for one batch of the same feed stream, their duration and related steps (predecessors), and the particular resources being used during those steps. The summary time diagrams are figures C-1, C-3, C-5, C-7, and C-9. The detailed process step listings are figures C-2, C-4, C-6, C-8, and C-10.

The information obtained from the Microsoft Project models is then summarized in Figure C-11. Figure C-11 contains the Microsoft Excel spreadsheet used for the 3 Adjustment Tanks Alternative calculations. The top part shows the information gathered from the models, and the middle and bottom parts are the result of the calculations described in Section 5.1 and replicated in Excel.

FIGURE C-1

Figure C-2 -- KE1 Process Steps for 3 Adjustment Tanks Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1	2
1	KE1 FEED STREAM	0 hrs				12:00 AM
2	Multiple batch example with the following provisions:	0 hrs				12:00 AM
3	3 Adjustment Tanks	0 hrs				12:00 AM
4	21 hours between batch starts	0 hrs				12:00 AM
5						
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank		
7	Configure Receiving Station	0.5 hrs				
8	Receive Sludge	1 hr	7			
9	Homogenize Feed	0.17 hrs	8			
10	Feed Screening Process	1 hr	9			
11						
12	Screen Process Feed (Batch 1)	2 hrs		Screening System		
13	Screen Feed	1 hr	10SS			
14	Run Flush Water As Needed	1 hr	10SS			
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank		
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS			
17	Send Screened Particles to Elutriation Column	1 hr	15FF			
18						
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column		
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs			
21	Operate Elutriation Column	1 hr	17SS			
22	Light Phase to Resin Buffer Tank	1 hr	21SS			
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS			
24						
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank		
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF			
27	Homogenize Sludge	0.17 hrs	26			
28	Transfer Sludge to Dissolver	8 hrs	27			
29						
30	Dissolve Sludge (Batch 1)	16.67 hrs		Dissolver		
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs			
32	Add Initial Reagents to Dissolver	0.5 hrs	31			
33	Start Agitator	0.08 hrs	32FS-0.08 hrs			
34	Heat Dissolver Contents	2 hrs	33			
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS			
36	Complete Reaction	4 hrs	35			
37	Cool Dissolver Contents	2 hrs	36			
38						
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	3.88 hrs		Dissolver		
40	Transfer 18 kg solids to Centrifuge (885 liters)	0.88 hrs	37			
41	Transfer 18 kg solids to Centrifuge (885 liters)	0.88 hrs	56			
42	Transfer Remaining Volume to Centrifuge (610 liters)	0.62 hrs	67			
43						
44	Centrifuge Dissolver Products (Batch 1)	4.71 hrs		Centrifuge		

Figure C-2 -- KE1 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
45	Start Centrifuge	0.08 hrs	40SS-0.08 hrs			
46	Clarify Feed From Dissolver	0.88 hrs	40SS			
47	Transfer Liquids to Clarified Liquid Tank	0.88 hrs	46SS			
48	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	46			
49	Flush Solids Cake With Water (60 liters)	0.08 hrs	48			
50	Homogenize Solids Cake and Water	0.08 hrs	49			
51	Recentrifuge Homogenized Slurry	0.17 hrs	50			
52	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	51SS			
53	Flush Solids Cake With Water (60 liters)	0.08 hrs	52			
54	Homogenize Solids Cake and Water	0.08 hrs	53			
55	Transfer Solution to Leaching Tank	0.08 hrs	54			
56	Prepare Centrifuge for more feed	0.08 hrs	55			
57	Clarify Feed From Dissolver	0.88 hrs	41SS			
58	Transfer Liquids to Clarified Liquid Tank	0.88 hrs	57SS			
59	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	57			
60	Flush Solids Cake With Water (60 liters)	0.08 hrs	59			
61	Homogenize Solids Cake and Water	0.08 hrs	60			
62	Recentrifuge Homogenized Slurry	0.17 hrs	61			
63	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	62SS			
64	Flush Solids Cake With Water (60 liters)	0.08 hrs	63			
65	Homogenize Solids Cake and Water	0.08 hrs	64			
66	Transfer Solution to Leaching Tank	0.08 hrs	65			
67	Prepare Centrifuge for more feed	0.08 hrs	66			
68	Clarify Feed From Dissolver	0.62 hrs	42SS			
69	Transfer Liquids to Clarified Liquid Tank	0.62 hrs	68SS			
70	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	68			
71	Flush Solids Cake With Water (60 liters)	0.08 hrs	70			
72	Homogenize Solids Cake and Water	0.08 hrs	71			
73	Recentrifuge Homogenized Slurry	0.17 hrs	72			
74	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	73SS			
75	Flush Solids Cake With Water (60 liters)	0.08 hrs	74			
76	Homogenize Solids Cake and Water	0.08 hrs	75			
77	Transfer Solution to Leaching Tank	0.08 hrs	76			
78	Prepare Centrifuge for more feed	0.08 hrs	77			
79						
80	Leach Rinsed Dissolver Solids (Batch 1)	7.57 hrs		Leaching Tank		
81	Receive Centrifuged Dissolver Slurry	0.08 hrs	55SS			
82	Receive Centrifuged Dissolver Slurry	0.08 hrs	66SS			
83	Receive Centrifuged Dissolver Slurry	0.08 hrs	77SS			
84	Add Leaching Reagents	0.5 hrs	83			
85	Homogenize Slurry to Aid Leaching	4 hrs	84			
86						
87	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	2.46 hrs		Leaching Tank		
88	Transfer 18 kg solids to Centrifuge (361 liters)	0.37 hrs	85			

Figure C-2 -- KE1 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
89	Transfer 18 kg solids to Centrifuge (361 liters)	0.37 hrs	104			
90	Transfer Remaining Volume to Centrifuge (195 liters)	0.2 hrs	115			
91						
92	Centrifuge Leached Dissolver Slurry (Batch 1)	3.31 hrs		Centrifuge		
93	Start Centrifuge	0.08 hrs	88SS-0.08 hrs			
94	Clarify Feed From Leaching Tank	0.37 hrs	88SS			
95	Transfer Liquids to Clarified Liquid Tank	0.37 hrs	94SS			
96	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	94			
97	Flush Solids Cake With Water (60 liters)	0.08 hrs	96			
98	Homogenize Solids Cake and Water	0.08 hrs	97			
99	Recentrifuge Homogenized Slurry	0.17 hrs	98			
100	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	99SS			
101	Flush Solids Cake With Water (75 liters)	0.1 hrs	100			
102	Homogenize Solids Cake and Water	0.08 hrs	101			
103	Transfer Solution to Solids Reception Tank	0.08 hrs	102			
104	Prepare Centrifuge for more feed	0.08 hrs	103			
105	Clarify Feed From Leaching Tank	0.37 hrs	89SS			
106	Transfer Liquids to Clarified Liquid Tank	0.37 hrs	105SS			
107	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	105			
108	Flush Solids Cake With Water (60 liters)	0.08 hrs	107			
109	Homogenize Solids Cake and Water	0.08 hrs	108			
110	Recentrifuge Homogenized Slurry	0.17 hrs	109			
111	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	110SS			
112	Flush Solids Cake With Water (75 liters)	0.1 hrs	111			
113	Homogenize Solids Cake and Water	0.08 hrs	112			
114	Transfer Solution to Solids Reception Tank	0.08 hrs	113			
115	Prepare Centrifuge for more feed	0.08 hrs	114			
116	Clarify Feed From Leaching Tank	0.2 hrs	90SS			
117	Transfer Liquids to Clarified Liquid Tank	0.2 hrs	116SS			
118	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	116			
119	Flush Solids Cake With Water (60 liters)	0.08 hrs	118			
120	Homogenize Solids Cake and Water	0.08 hrs	119			
121	Recentrifuge Homogenized Slurry	0.17 hrs	120			
122	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	121SS			
123	Flush Solids Cake With Water (75 liters)	0.1 hrs	122			
124	Homogenize Solids Cake and Water	0.08 hrs	123			
125	Transfer Solution to Solids Reception Tank	0.08 hrs	124			
126	Prepare Centrifuge for more feed	0.08 hrs	125			
127						
128	Store Clarified Liquid (Batch 1)	12.56 hrs		Clarified Liquid Tank		
129	Receive Clarified Dissolver Liquids From Centrifuge	0.88 hrs	47SS			
130	Receive Wash Liquids From Centrifuge	0.17 hrs	52SS			
131	Receive Clarified Dissolver Liquids From Centrifuge	0.88 hrs	58SS			
132	Receive Wash Liquids From Centrifuge	0.17 hrs	63SS			

Figure C-2 -- KE1 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
133	Receive Clarified Dissolver Liquids From Centrifuge	0.62 hrs	89SS			
134	Receive Wash Liquids From Centrifuge	0.17 hrs	74SS			
135	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.37 hrs	95SS			
136	Receive Wash Liquids From Centrifuge	0.17 hrs	100SS			
137	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.37 hrs	106SS			
138	Receive Wash Liquids From Centrifuge	0.17 hrs	111SS			
139	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.2 hrs	117SS			
140	Receive Wash Liquids From Centrifuge	0.17 hrs	122SS			
141	Transfer Clarified Liquid to Cartridge Filter	0.47 hrs	140FS+0.17 hrs			
142						
143	Filter Clarified Liquid (Batch 1)	1.07 hrs		Cartridge Filter		
144	Process Clarified Liquid Through Cartridge Filter	0.47 hrs	141SS			
145	Transfer Filtered Liquid to Adjustment Tank	0.47 hrs	144SS			
146	Rinse Cartridge Filter	0.5 hrs	145			
147	Changeout Cartridge Filter	0 hrs	146FS+0.1 hrs			
148	Send Used Cartridge Filter to Final Conditioning	0 hrs	147			
149						
150	Adjust Filtered Liquid (Batch 1)	60.47 hrs		Adjustment Tank 1		
151	Receive and Store Filtered Liquid	0.97 hrs	145SS			
152	Sample and Wait For Results	48 hrs	151			
153	Add Adjustment Reagents (~2 liters)	0.25 hrs	152			
154	Homogenize Adjusted Liquid	0.25 hrs	153			
155	Transfer Adjusted Liquid to Neutralization Tank	1 hr	154			
156						
157	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank		
158	Receive and Store Adjusted Liquid	1.08 hrs	155SS			
159	Add Neutralization Reagents	1 hr	158			
160	Homogenize and Cool Neutralized Slurry	2 hrs	159			
161	Sample Slurry to Confirm TWRS Acceptability	0 hrs	160			
162	Transfer Neutralized Slurry to Transport System	1.5 hrs	161			
163						
164	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport		
165	Receive and Load Neutralized Slurry	1.5 hrs	162SS			
166	Transport Slurry to Tank Farms	8 hrs	165			
167						
168	END BATCH 1	0 hrs				
169	This marks the end of batch 1	0 hrs	166			
170						
171						
172	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank		
173	Configure Receiving Station	0.5 hrs	75SS+21 hrs			
174	Receive Sludge	1 hr	173			
175	Homogenize Feed	0.17 hrs	174			
176	Feed Screening Process	1 hr	175			

Figure C-4 -- KE2 Process Steps for 3 Adjustment Tanks Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1
1	KE2 FEED STREAM	0 hrs			12:
2	Multiple batch example with the following provisions:	0 hrs			12:0
3	3 Adjustment Tanks	0 hrs			12:0
4	32 hours between batch starts	0 hrs			12:0
5					
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank	
7	Configure Receiving Station	0.5 hrs			
8	Receive Sludge	1 hr	7		
9	Homogenize Feed	0.17 hrs	8		
10	Feed Screening Process	1 hr	9		
11					
12	Screen Process Feed (Batch 1)	2 hrs		Screening System	
13	Screen Feed	1 hr	10SS		
14	Run Flush Water As Needed	1 hr	10SS		
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank	
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS		
17	Send Screened Particles to Elutriation Column	1 hr	15FF		
18					
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column	
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs		
21	Operate Elutriation Column	1 hr	17SS		
22	Light Phase to Resin Buffer Tank	1 hr	21SS		
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS		
24					
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank	
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF		
27	Homogenize Sludge	0.17 hrs	26		
28	Transfer Sludge to Dissolver	8 hrs	27		
29					
30	Dissolve Sludge (Batch 1)	28.67 hrs		Dissolver	
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs		
32	Add Initial Reagents to Dissolver	0.5 hrs	31		
33	Start Agitator	0.08 hrs	32FS-0.08 hrs		
34	Heat Dissolver Contents	2 hrs	33		
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS		
36	Complete Reaction	16 hrs	35		
37	Cool Dissolver Contents	2 hrs	36		
38					
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.45 hrs		Dissolver	
40	Transfer 11.6 kg solids to Centrifuge (2451 liters)	2.45 hrs	37		

Figure C-4 -- KE2 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
41					
42	Centrifuge Dissolver Products (Batch 1)	3.28 hrs		Centrifuge	
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs		
44	Clarify Feed From Dissolver	2.45 hrs	40SS		
45	Transfer Liquids to Clarified Liquid Tank	2.45 hrs	44SS		
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44		
47	Flush Solids Cake With Water (60 liters)	0.08 hrs	46		
48	Homogenize Solids Cake and Water	0.08 hrs	47		
49	Recentrifuge Homogenized Slurry	0.17 hrs	48		
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS		
51	Flush Solids Cake With Water (60 liters)	0.08 hrs	50		
52	Homogenize Solids Cake and Water	0.08 hrs	51		
53	Transfer Solution to Leaching Tank	0.08 hrs	52		
54	Prepare Centrifuge for more feed	0.08 hrs	53		
55					
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank	
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS		
58	Add Leaching Reagents	0.5 hrs	57		
59	Homogenize Slurry to Aid Leaching	4 hrs	58		
60					
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.22 hrs		Leaching Tank	
62	Transfer 10.9 kg solids to Centrifuge (218 liters)	0.22 hrs	59		
63					
64	Centrifuge Leached Dissolver Slurry (Batch 1)	1.07 hrs		Centrifuge	
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs		
66	Clarify Feed From Leaching Tank	0.22 hrs	62SS		
67	Transfer Liquids to Clarified Liquid Tank	0.22 hrs	68SS		
68	Stop Centrifuge When Clarification Complete	0.08 hrs	68		
69	Flush Solids Cake With Water (60 liters)	0.08 hrs	68		
70	Homogenize Solids Cake and Water	0.08 hrs	69		
71	Recentrifuge Homogenized Slurry	0.17 hrs	70		
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS		
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72		
74	Homogenize Solids Cake and Water	0.08 hrs	73		
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74		
76	Prepare Centrifuge for more feed	0.08 hrs	75		
77					
78	Store Clarified Liquid (Batch 1)	8.78 hrs		Clarified Liquid Tank	
79	Receive Clarified Dissolver Liquids From Centrifuge	2.45 hrs	45SS		
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS		

Figure C-4 -- KE2 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.22 hrs	67SS		
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS		
83	Transfer Clarified Liquid to Cartridge Filter	0.36 hrs	82FS+0.17 hrs		
84					
85	Filter Clarified Liquid (Batch 1)	0.96 hrs		Cartridge Filter	
86	Process Clarified Liquid Through Cartridge Filter	0.36 hrs	83SS		
87	Transfer Filtered Liquid to Adjustment Tank	0.36 hrs	86SS		
88	Rinse Cartridge Filter	0.5 hrs	87		
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs		
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89		
91					
92	Adjust Filtered Liquid (Batch 1)	50.9 hrs		Adjustment Tank 1	
93	Receive and Store Filtered Liquid	0.86 hrs	87SS		
94	Sample and Wait For Results	48 hrs	93		
95	Add Adjustment Reagents (~1010 liters)	0.79 hrs	94		
96	Homogenize Adjusted Liquid	0.25 hrs	95		
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96		
98					
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank	
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS		
101	Add Neutralization Reagents	1 hr	100		
102	Homogenize and Cool Neutralized Slurry	2 hrs	101		
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102		
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103		
105					
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport	
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS		
108	Transport Slurry to Tank Farms	8 hrs	107		
109					
110	END BATCH 1	0 hrs			
111	This marks the end of batch 1	0 hrs	108		
112					
113					
114	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank	
115	Configure Receiving Station	0.5 hrs	7SS+32 hrs		
116	Receive Sludge	1 hr	115		
117	Homogenize Feed	0.17 hrs	116		
118	Feed Screening Process	1 hr	117		
119					
120	Screen Process Feed (Batch 2)	2 hrs		Screening System	

Figure C-6 -- KW1 Process Steps for 3 Adjustment Tanks Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1	2
1	KW1 FEED STREAM	0 hrs				
2	Multiple batch example with the following provisions:	0 hrs			12:00 AM	
3	3 Adjustment Tanks	0 hrs			12:00 AM	
4	21 hours between batch starts	0 hrs			12:00 AM	
5						
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank		
7	Configure Receiving Station	0.5 hrs				
8	Receive Sludge	1 hr	7			
9	Homogenize Feed	0.17 hrs	8			
10	Feed Scrubbing Process	1 hr	9			
11						
12	Screen Process Feed (Batch 1)	2 hrs		Screening System		
13	Screen Feed	1 hr	10SS			
14	Run Flush Water As Needed	1 hr	10SS			
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank		
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS			
17	Send Screened Particles to Elutriation Column	1 hr	15FF			
18						
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column		
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs			
21	Operate Elutriation Column	1 hr	17SS			
22	Light Phase to Resin Buffer Tank	1 hr	21SS			
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS			
24						
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank		
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF			
27	Homogenize Sludge	0.17 hrs	26			
28	Transfer Sludge to Dissolver	8 hrs	27			
29						
30	Dissolve Sludge (Batch 1)	14.67 hrs		Dissolver		
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs			
32	Add Initial Reagents to Dissolver	0.5 hrs	31			
33	Start Agitator	0.08 hrs	32FS-0.08 hrs			
34	Heat Dissolver Contents	2 hrs	33			
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS			
36	Complete Reaction	2 hrs	35			
37	Cool Dissolver Contents	2 hrs	36			
38						
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	5.99 hrs		Dissolver		
40	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	37			
41	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	59			
42	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	70			
43	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	81			
44	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	92			

Figure C-6 -- KW1 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
45	Transfer Remaining Volume to Centrifuge (355 liters)	0.36 hrs	103			
46						
47	Centrifuge Dissolver Products (Batch 1)	6.82 hrs		Centrifuge		
48	Start Centrifuge	0.08 hrs	40SS-0.08 hrs			
49	Clarify Feed From Dissolver	0.38 hrs	40SS			
50	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	49SS			
51	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	49			
52	Flush Solids Cake With Water (60 liters)	0.08 hrs	51			
53	Homogenize Solids Cake and Water	0.08 hrs	52			
54	Recentrifuge Homogenized Slurry	0.17 hrs	53			
55	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	54SS			
56	Flush Solids Cake With Water (60 liters)	0.08 hrs	55			
57	Homogenize Solids Cake and Water	0.08 hrs	56			
58	Transfer Solution to Leaching Tank	0.08 hrs	57			
59	Prepare Centrifuge for more feed	0.08 hrs	58			
60	Clarify Feed From Dissolver	0.38 hrs	41SS			
61	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	60SS			
62	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	60			
63	Flush Solids Cake With Water (60 liters)	0.08 hrs	62			
64	Homogenize Solids Cake and Water	0.08 hrs	63			
65	Recentrifuge Homogenized Slurry	0.17 hrs	64			
66	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	65SS			
67	Flush Solids Cake With Water (60 liters)	0.08 hrs	66			
68	Homogenize Solids Cake and Water	0.08 hrs	67			
69	Transfer Solution to Leaching Tank	0.08 hrs	68			
70	Prepare Centrifuge for more feed	0.08 hrs	69			
71	Clarify Feed From Dissolver	0.38 hrs	42SS			
72	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	71SS			
73	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	71			
74	Flush Solids Cake With Water (60 liters)	0.08 hrs	73			
75	Homogenize Solids Cake and Water	0.08 hrs	74			
76	Recentrifuge Homogenized Slurry	0.17 hrs	75			
77	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	76SS			
78	Flush Solids Cake With Water (60 liters)	0.08 hrs	77			
79	Homogenize Solids Cake and Water	0.08 hrs	78			
80	Transfer Solution to Leaching Tank	0.08 hrs	79			
81	Prepare Centrifuge for more feed	0.08 hrs	80			
82	Clarify Feed From Dissolver	0.38 hrs	43SS			
83	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	82SS			
84	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	82			
85	Flush Solids Cake With Water (60 liters)	0.08 hrs	84			
86	Homogenize Solids Cake and Water	0.08 hrs	85			
87	Recentrifuge Homogenized Slurry	0.17 hrs	86			
88	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	87SS			

Figure C-6 -- KW1 Process Steps for 3 Adjustment Tanks Alternative (cont.)

10	Task Name	Duration	Predecessors	Resource Names	1	2
89	Flush Solids Cake With Water (60 liters)	0.08 hrs	88			
90	Homogenize Solids Cake and Water	0.08 hrs	89			
91	Transfer Solution to Leaching Tank	0.08 hrs	90			
92	Prepare Centrifuge for more feed	0.08 hrs	91			
93	Clarify Feed From Dissolver	0.38 hrs	44SS			
94	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	93SS			
95	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	93			
96	Flush Solids Cake With Water (60 liters)	0.08 hrs	95			
97	Homogenize Solids Cake and Water	0.08 hrs	96			
98	Recentrifuge Homogenized Slurry	0.17 hrs	97			
99	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	98SS			
100	Flush Solids Cake With Water (60 liters)	0.08 hrs	99			
101	Homogenize Solids Cake and Water	0.08 hrs	100			
102	Transfer Solution to Leaching Tank	0.08 hrs	101			
103	Prepare Centrifuge for more feed	0.08 hrs	102			
104	Clarify Feed From Dissolver	0.36 hrs	45SS			
105	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	104SS			
106	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	104			
107	Flush Solids Cake With Water (60 liters)	0.08 hrs	106			
108	Homogenize Solids Cake and Water	0.08 hrs	107			
109	Recentrifuge Homogenized Slurry	0.17 hrs	108			
110	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	109SS			
111	Flush Solids Cake With Water (60 liters)	0.08 hrs	110			
112	Homogenize Solids Cake and Water	0.08 hrs	111			
113	Transfer Solution to Leaching Tank	0.08 hrs	112			
114	Prepare Centrifuge for more feed	0.08 hrs	113			
115						
116	Leach Rinsed Dissolver Solids (Batch 1)	10.19 hrs		Leaching Tank		
117	Receive Centrifuged Dissolver Slurry	0.08 hrs	58SS			
118	Receive Centrifuged Dissolver Slurry	0.08 hrs	69SS			
119	Receive Centrifuged Dissolver Slurry	0.08 hrs	60SS			
120	Receive Centrifuged Dissolver Slurry	0.08 hrs	91SS			
121	Receive Centrifuged Dissolver Slurry	0.08 hrs	102SS			
122	Receive Centrifuged Dissolver Slurry	0.08 hrs	113SS			
123	Add Leaching Reagents	0.5 hrs	122			
124	Homogenize Slurry to Aid Leaching	4 hrs	123			
125						
126	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	5.85 hrs		Leaching Tank		
127	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	124			
128	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	146			
129	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	157			
130	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	168			
131	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	179			
132	Transfer Remaining Volume to Centrifuge (228 liters)	0.23 hrs	190			

Figure C-6 -- KW1 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
133						
134	Centrifuge Leached Dissolver Slurry (Batch 1)	6.69 hrs		Centrifuge		
135	Start Centrifuge	0.08 hrs	127SS-0.08 hrs			
136	Clarify Feed From Leaching Tank	0.36 hrs	127SS			
137	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	136SS			
138	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	136			
139	Flush Solids Cake With Water (60 liters)	0.08 hrs	138			
140	Homogenize Solids Cake and Water	0.08 hrs	139			
141	Recentrifuge Homogenized Slurry	0.17 hrs	140			
142	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	141SS			
143	Flush Solids Cake With Water (75 liters)	0.1 hrs	142			
144	Homogenize Solids Cake and Water	0.08 hrs	143			
145	Transfer Solution to Solids Reception Tank	0.08 hrs	144			
146	Prepare Centrifuge for more feed	0.08 hrs	145			
147	Clarify Feed From Leaching Tank	0.36 hrs	128SS			
148	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	147SS			
149	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	147			
150	Flush Solids Cake With Water (60 liters)	0.08 hrs	149			
151	Homogenize Solids Cake and Water	0.08 hrs	150			
152	Recentrifuge Homogenized Slurry	0.17 hrs	151			
153	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	152SS			
154	Flush Solids Cake With Water (75 liters)	0.1 hrs	153			
155	Homogenize Solids Cake and Water	0.08 hrs	154			
156	Transfer Solution to Solids Reception Tank	0.08 hrs	155			
157	Prepare Centrifuge for more feed	0.08 hrs	156			
158	Clarify Feed From Leaching Tank	0.36 hrs	129SS			
159	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	158SS			
160	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	158			
161	Flush Solids Cake With Water (60 liters)	0.08 hrs	160			
162	Homogenize Solids Cake and Water	0.08 hrs	161			
163	Recentrifuge Homogenized Slurry	0.17 hrs	162			
164	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	163SS			
165	Flush Solids Cake With Water (75 liters)	0.1 hrs	164			
166	Homogenize Solids Cake and Water	0.08 hrs	165			
167	Transfer Solution to Solids Reception Tank	0.08 hrs	166			
168	Prepare Centrifuge for more feed	0.08 hrs	167			
169	Clarify Feed From Leaching Tank	0.36 hrs	130SS			
170	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	169SS			
171	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	169			
172	Flush Solids Cake With Water (60 liters)	0.08 hrs	171			
173	Homogenize Solids Cake and Water	0.08 hrs	172			
174	Recentrifuge Homogenized Slurry	0.17 hrs	173			
175	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	174SS			
176	Flush Solids Cake With Water (75 liters)	0.1 hrs	175			

Figure C-6 -- KW1 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
177	Homogenize Solids Cake and Water	0.08 hrs	176			
178	Transfer Solution to Solids Reception Tank	0.08 hrs	177			
179	Prepare Centrifuge for more feed	0.08 hrs	178			
180	Clarify Feed From Leaching Tank	0.36 hrs	131SS			
181	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	180SS			
182	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	180			
183	Flush Solids Cake With Water (60 liters)	0.08 hrs	182			
184	Homogenize Solids Cake and Water	0.08 hrs	183			
185	Recentrifuge Homogenized Slurry	0.17 hrs	184			
186	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	185SS			
187	Flush Solids Cake With Water (75 liters)	0.1 hrs	186			
188	Homogenize Solids Cake and Water	0.08 hrs	187			
189	Transfer Solution to Solids Reception Tank	0.08 hrs	188			
190	Prepare Centrifuge for more feed	0.08 hrs	189			
191	Clarify Feed From Leaching Tank	0.23 hrs	132SS			
192	Transfer Liquids to Clarified Liquid Tank	0.23 hrs	191SS			
193	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	191			
194	Flush Solids Cake With Water (60 liters)	0.08 hrs	193			
195	Homogenize Solids Cake and Water	0.08 hrs	194			
196	Recentrifuge Homogenized Slurry	0.17 hrs	195			
197	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	196SS			
198	Flush Solids Cake With Water (75 liters)	0.1 hrs	197			
199	Homogenize Solids Cake and Water	0.08 hrs	198			
200	Transfer Solution to Solids Reception Tank	0.08 hrs	199			
201	Prepare Centrifuge for more feed	0.08 hrs	200			
202						
203	Store Clarified Liquid (Batch 1)	18.2 hrs		Clarified Liquid Tank		
204	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	50SS			
205	Receive Wash Liquids From Centrifuge	0.17 hrs	55SS			
206	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	61SS			
207	Receive Wash Liquids From Centrifuge	0.17 hrs	66SS			
208	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	72SS			
209	Receive Wash Liquids From Centrifuge	0.17 hrs	77SS			
210	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	83SS			
211	Receive Wash Liquids From Centrifuge	0.17 hrs	88SS			
212	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	94SS			
213	Receive Wash Liquids From Centrifuge	0.17 hrs	99SS			
214	Receive Clarified Dissolver Liquids From Centrifuge	0.36 hrs	105SS			
215	Receive Wash Liquids From Centrifuge	0.17 hrs	110SS			
216	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	137SS			
217	Receive Wash Liquids From Centrifuge	0.17 hrs	142SS			
218	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	148SS			
219	Receive Wash Liquids From Centrifuge	0.17 hrs	153SS			
220	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	159SS			

Figure C-6 -- KW1 Process Steps for 3 Adjustment Tanks Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
221	Receive Wash Liquids From Centrifuge	0.17 hrs	164SS			
222	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	170SS			
223	Receive Wash Liquids From Centrifuge	0.17 hrs	175SS			
224	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	181SS			
225	Receive Wash Liquids From Centrifuge	0.17 hrs	186SS			
226	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.23 hrs	192SS			
227	Receive Wash Liquids From Centrifuge	0.17 hrs	197SS			
228	Transfer Clarified Liquid to Cartridge Filter	0.61 hrs	227FS+0.17 hrs			
229						
230	Filter Clarified Liquid (Batch 1)	1.21 hrs		Cartridge Filter		
231	Process Clarified Liquid Through Cartridge Filter	0.61 hrs	228SS			
232	Transfer Filtered Liquid to Adjustment Tank	0.61 hrs	231SS			
233	Rinse Cartridge Filter	0.5 hrs	232			
234	Changeout Cartridge Filter	0 hrs	233FS+0.1 hrs			
235	Send Used Cartridge Filter to Final Conditioning	0 hrs	234			
236						
237	Adjust Filtered Liquid (Batch 1)	50.61 hrs		Adjustment Tank 1		
238	Receive and Store Filtered Liquid	1.11 hrs	232SS			
239	Sample and Wait For Results	48 hrs	238			
240	Add Adjustment Reagents (~1 liters)	0.25 hrs	239			
241	Homogenize Adjusted Liquid	0.25 hrs	240			
242	Transfer Adjusted Liquid to Neutralization Tank	1 hr	241			
243						
244	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank		
245	Receive and Store Adjusted Liquid	1.08 hrs	242SS			
246	Add Neutralization Reagents	1 hr	245			
247	Homogenize and Cool Neutralized Slurry	2 hrs	246			
248	Sample Slurry to Confirm TWRS Acceptability	0 hrs	247			
249	Transfer Neutralized Slurry to Transport System	1.5 hrs	248			
250						
251	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport		
252	Receive and Load Neutralized Slurry	1.5 hrs	249SS			
253	Transport Slurry to Tank Farms	8 hrs	252			
254						
255	END BATCH 1	0 hrs				
256	This marks the end of batch 1	0 hrs	253			
257						
258						
259	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank		
260	Configure Receiving Station	0.5 hrs	75S+21 hrs			
261	Receive Sludge	1 hr	260			
262	Homogenize Feed	0.17 hrs	261			
263	Feed Screening Process	1 hr	262			
264						

Figure C-8 -- KW2 Process Steps for 3 Adjustment Tank Alternative

ID	Task Name	Duration	Predecessors	Resource Names	
1	KW2 FEED STREAM	0 hrs			1
2	Multiple batch example with the following provisions:	0 hrs			12:
3	3 Adjustment Tanks	0 hrs			12:
4	36 hours between batch starts	0 hrs			12:
5					
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank	
7	Configure Receiving Station	0.5 hrs			
8	Receive Sludge	1 hr	7		
9	Homogenize Feed	0.17 hrs	8		
10	Feed Screening Process	1 hr	9		
11					
12	Screen Process Feed (Batch 1)	2 hrs		Screening System	
13	Screen Feed	1 hr	10SS		
14	Run Flush Water As Needed	1 hr	10SS		
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank	
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS		
17	Send Screened Particles to Elutriation Column	1 hr	15FF		
18					
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column	
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs		
21	Operate Elutriation Column	1 hr	17SS		
22	Light Phase to Resin Buffer Tank	1 hr	21SS		
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS		
24					
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank	
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF		
27	Homogenize Sludge	0.17 hrs	26		
28	Transfer Sludge to Dissolver	8 hrs	27		
29					
30	Dissolve Sludge (Batch 1)	32.67 hrs		Dissolver	
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs		
32	Add Initial Reagents to Dissolver	0.5 hrs	31		
33	Start Agitator	0.08 hrs	32FS-0.08 hrs		
34	Heat Dissolver Contents	2 hrs	33		
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS		
36	Complete Reaction	20 hrs	35		
37	Cool Dissolver Contents	2 hrs	36		
38					
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.44 hrs		Dissolver	
40	Transfer 12.9 kg solids to Centrifuge (2441 liters)	2.44 hrs	37		

Figure C-8 -- KW2 Process Steps for 3 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
41				
42	Centrifuge Dissolver Products (Batch 1)	3.27 hrs		Centrifuge
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs	
44	Clarify Feed From Dissolver	2.44 hrs	40SS	
45	Transfer Liquids to Clarified Liquid Tank	2.44 hrs	44SS	
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44	
47	Flush Solids Cake With Water (60 liters)	0.08 hrs	46	
48	Homogenize Solids Cake and Water	0.08 hrs	47	
49	Recentrifuge Homogenized Slurry	0.17 hrs	48	
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS	
51	Flush Solids Cake With Water (60 liters)	0.08 hrs	50	
52	Homogenize Solids Cake and Water	0.08 hrs	51	
53	Transfer Solution to Leaching Tank	0.08 hrs	52	
54	Prepare Centrifuge for more feed	0.08 hrs	53	
55				
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS	
58	Add Leaching Reagents	0.5 hrs	57	
59	Homogenize Slurry to Aid Leaching	4 hrs	58	
60				
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.25 hrs		Leaching Tank
62	Transfer 12.2 kg solids to Centrifuge (245 liters)	0.25 hrs	59	
63				
64	Centrifuge Leached Dissolver Slurry (Batch 1)	1.1 hrs		Centrifuge
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs	
66	Clarify Feed From Leaching Tank	0.25 hrs	62SS	
67	Transfer Liquids to Clarified Liquid Tank	0.25 hrs	66SS	
68	Stop Centrifuge When Clarification Complete	0.08 hrs	66	
69	Flush Solids Cake With Water (60 liters)	0.08 hrs	68	
70	Homogenize Solids Cake and Water	0.08 hrs	69	
71	Recentrifuge Homogenized Slurry	0.17 hrs	70	
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS	
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72	
74	Homogenize Solids Cake and Water	0.08 hrs	73	
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74	
76	Prepare Centrifuge for more feed	0.08 hrs	75	
77				
78	Store Clarified Liquid (Batch 1)	8.81 hrs		Clarified Liquid Tank
79	Receive Clarified Dissolver Liquids From Centrifuge	2.44 hrs	45SS	
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS	

Figure C-8 -- KW2 Process Steps for 3 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.25 hrs	67SS	
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS	
83	Transfer Clarified Liquid to Cartridge Filter	0.37 hrs	82FS+0.17 hrs	
84				
85	Filter Clarified Liquid (Batch 1)	0.97 hrs		Cartridge Filter
86	Process Clarified Liquid Through Cartridge Filter	0.37 hrs	83SS	
87	Transfer Filtered Liquid to Adjustment Tank	0.37 hrs	86SS	
88	Rinse Cartridge Filter	0.5 hrs	87	
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs	
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89	
91				
92	Adjust Filtered Liquid (Batch 1)	51.12 hrs		Adjustment Tank 1
93	Receive and Store Filtered Liquid	0.87 hrs	87SS	
94	Sample and Wait For Results	48 hrs	93	
95	Add Adjustment Reagents (~1279 liters)	1 hr	94	
96	Homogenize Adjusted Liquid	0.25 hrs	95	
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96	
98				
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS	
101	Add Neutralization Reagents	1 hr	100	
102	Homogenize and Cool Neutralized Slurry	2 hrs	101	
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102	
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103	
105				
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS	
108	Transport Slurry to Tank Farms	8 hrs	107	
109				
110	END BATCH 1	0 hrs		
111	This marks the end of batch 1	0 hrs	108	
112				
113				
114	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank
115	Configure Receiving Station	0.5 hrs	7SS+36 hrs	
116	Receive Sludge	1 hr	115	
117	Homogenize Feed	0.17 hrs	116	
118	Feed Screening Process	1 hr	117	
119				
120	Screen Process Feed (Batch 2)	2 hrs		Screening System

FIGURE C-9

Figure C-10 -- KW3 Process Steps for 3 Adjustment Tank Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1
1	KW3 FEED STREAM	0 hrs			12:
2	Multiple batch example with the following provisions:	0 hrs			12:0
3	3 Adjustment Tanks	0 hrs			12:0
4	28 hours between batch starts	0 hrs			12:0
5					
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank	
7	Configure Receiving Station	0.5 hrs			
8	Receive Sludge	1 hr	7		
9	Homogenize Feed	0.17 hrs	8		
10	Feed Screening Process	1 hr	9		
11					
12	Screen Process Feed (Batch 1)	2 hrs		Screening System	
13	Screen Feed	1 hr	10SS		
14	Run Flush Water As Needed	1 hr	10SS		
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank	
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS		
17	Send Screened Particles to Elutriation Column	1 hr	16FF		
18					
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column	
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs		
21	Operate Elutriation Column	1 hr	17SS		
22	Light Phase to Resin Buffer Tank	1 hr	21SS		
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS		
24					
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank	
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF		
27	Homogenize Sludge	0.17 hrs	26		
28	Transfer Sludge to Dissolver	8 hrs	27		
29					
30	Dissolve Sludge (Batch 1)	24.67 hrs		Dissolver	
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs		
32	Add Initial Reagents to Dissolver	0.5 hrs	31		
33	Start Agitator	0.08 hrs	32FS-0.08 hrs		
34	Heat Dissolver Contents	2 hrs	33		
35	Recieve Sludge From Sludge Buffer Tank	8 hrs	28SS		
36	Complete Reaction	12 hrs	35		
37	Cool Dissolver Contents	2 hrs	36		
38					
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.44 hrs		Dissolver	
40	Transfer 5.63 kg solids to Centrifuge (2498 liters)	2.44 hrs	37		

Figure C-10 -- KW3 Process Steps for 3 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
41					
42	Centrifuge Dissolver Products (Batch 1)	3.27 hrs		Centrifuge	
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs		
44	Clarify Feed From Dissolver	2.44 hrs	40SS		
45	Transfer Liquids to Clarified Liquid Tank	2.44 hrs	44SS		
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44		
47	Flush Solids Cake With Water (80 liters)	0.08 hrs	46		
48	Homogenize Solids Cake and Water	0.08 hrs	47		
49	Recentrifuge Homogenized Slurry	0.17 hrs	48		
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS		
51	Flush Solids Cake With Water (80 liters)	0.08 hrs	50		
52	Homogenize Solids Cake and Water	0.08 hrs	51		
53	Transfer Solution to Leaching Tank	0.08 hrs	52		
54	Prepare Centrifuge for more feed	0.08 hrs	53		
55					
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank	
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS		
58	Add Leaching Reagents	0.5 hrs	57		
59	Homogenize Slurry to Aid Leaching	4 hrs	58		
60					
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.11 hrs		Leaching Tank	
62	Transfer 5.3 kg solids to Centrifuge (107 liters)	0.11 hrs	59		
63					
64	Centrifuge Leached Dissolver Slurry (Batch 1)	0.96 hrs		Centrifuge	
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs		
66	Clarify Feed From Leaching Tank	0.11 hrs	62SS		
67	Transfer Liquids to Clarified Liquid Tank	0.11 hrs	66SS		
68	Stop Centrifuge When Clarification Complete	0.08 hrs	66		
69	Flush Solids Cake With Water (80 liters)	0.08 hrs	68		
70	Homogenize Solids Cake and Water	0.08 hrs	69		
71	Recentrifuge Homogenized Slurry	0.17 hrs	70		
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS		
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72		
74	Homogenize Solids Cake and Water	0.08 hrs	73		
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74		
76	Prepare Centrifuge for more feed	0.08 hrs	75		
77					
78	Store Clarified Liquid (Batch 1)	8.63 hrs		Clarified Liquid Tank	
79	Receive Clarified Dissolver Liquids From Centrifuge	2.44 hrs	45SS		
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS		

Figure C-10 -- KW3 Process Steps for 3 Adjustment Tank Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.11 hrs	67SS		
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS		
83	Transfer Clarified Liquid to Cartridge Filter	0.33 hrs	82FS+0.17 hrs		
84					
85	Filter Clarified Liquid (Batch 1)	0.93 hrs		Cartridge Filter	
86	Process Clarified Liquid Through Cartridge Filter	0.33 hrs	83SS		
87	Transfer Filtered Liquid to Adjustment Tank	0.33 hrs	86SS		
88	Rinse Cartridge Filter	0.5 hrs	87		
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs		
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89		
91					
92	Adjust Filtered Liquid (Batch 1)	50.96 hrs		Adjustment Tank 1	
93	Receive and Store Filtered Liquid	0.83 hrs	87SS		
94	Sample and Wait For Results	48 hrs	93		
95	Add Adjustment Reagents (~1121 liters)	0.88 hrs	94		
96	Homogenize Adjusted Liquid	0.25 hrs	95		
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96		
98					
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank	
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS		
101	Add Neutralization Reagents	1 hr	100		
102	Homogenize and Cool Neutralized Slurry	2 hrs	101		
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102		
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103		
105					
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport	
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS		
108	Transport Slurry to Tank Farms	8 hrs	107		
109					
110	END BATCH 1	0 hrs			
111	This marks the end of batch 1	0 hrs	108		
112					
113					
114	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank	
115	Configure Receiving Station	0.5 hrs	7SS+28 hrs		
116	Receive Sludge	1 hr	115		
117	Homogenize Feed	0.17 hrs	116		
118	Feed Screening Process	1 hr	117		
119					
120	Screen Process Feed (Batch 2)	2 hrs		Screening System	

Figure C-11– Excel Spreadsheet Calculation Display

3 Adjustment Tank Alternative

	KE1	KE2	KW1	KW2	KW3
Hours between batch starts	21	32	21	36	28
Hours to get batch completely into adjustment tank	32	40	36	44	36
Hours until batch is out of adjustment tank	81	90	85	94	86
Hours beginning to end for one batch	93	103	98	107	99
Total Processing Hours Added by Resin Processing	132	9	0	0	9
Total Batches for feed stream	146.1	24.4	11.2	10.2	22.4

The following numbers are derived starting with the equation $(n-1) \times (\text{time between batch starts}) = \text{start of batch } n$
All values are in hours, and assumes a cleaning every 10 batches unless otherwise stated.

	Batch 10 start	Cleaning Start	Batch 11 Start	Batch 11 Start without cleaning	Time added per batch by cleaning	New Batch Start Equivalent	End Time of Final Batch	End Time of Final Batch Without Cleaning
KE1	189	230	254	219	3.5	24.5	3780.0	3272.1
KE2	288	328	352	320	3.2	35.2	935.7	860.8
KW1	189	225	249	210	3.9	24.9	352.0	312.2
KW2	324	368	392	360	3.2	39.2	467.6	438.2
KW3	252	288	312	280	3.2	31.2	775.7	707.2
		Time to Process Stream with Cleaning (Days)	Time to Process Stream without Cleaning (Days)					
KE1	157.5	136.3						
KE2	39.0	35.9						
KW1	14.7	13.0						
KW2	19.5	18.3						
KW3	32.3	29.5						
Total	263.0	232.9						

APPENDIX D

SUPPORT INFORMATION AND CALCULATION RESULTS FOR THE 3 ADJUSTMENT TANKS AND 2 DISSOLVERS ALTERNATIVE

This appendix contains the complete set of Microsoft Project produced summary time diagrams for the 3 Adjustment Tanks and 2 Dissolvers Alternative. The summary time diagrams contain the summary process steps for 4 consecutive batches. They do not include the processing of elutriation column light phases, cleaning/maintenance activities, or the grouting processes. Following each summary time diagram is a listing of all process steps for one batch of the same feed stream, their duration and related steps (predecessors), and the particular resources being used during those steps. The summary time diagrams are figures D-1, D-3, D-5, D-7, and D-9. The detailed process step listings are figures D-2, D-4, D-6, D-8, and D-10.

The information obtained from the Microsoft Project models is then summarized in Figure D-11. Figure D-11 contains the Microsoft Excel spreadsheet used for the 3 Adjustment Tanks and 2 Dissolvers Alternative calculations. The top part shows the information gathered from the models, and the middle and bottom parts are the result of the calculations described in Section 5.1 and replicated in Excel.

FIGURE D-1

Figure D-2 -- KE1 Process Steps for 3 Adj. Tanks & 2 Dissolver Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1	2
1	KE1 FEED STREAM	0 hrs				12:00 AM
2	Multiple batch example with the following provisions:	0 hrs				12:00 AM
3	3 Adjustment Tanks, 2 Dissolvers	0 hrs				12:00 AM
4	17 hours between batch starts	0 hrs				12:00 AM
5						
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank		
7	Configure Receiving Station	0.5 hrs				
8	Receive Sludge	1 hr	7			
9	Homogenize Feed	0.17 hrs	8			
10	Feed Screening Process	1 hr	9			
11						
12	Screen Process Feed (Batch 1)	2 hrs		Screening System		
13	Screen Feed	1 hr	10SS			
14	Run Flush Water As Needed	1 hr	10SS			
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank		
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS			
17	Send Screened Particles to Elutriation Column	1 hr	15FF			
18						
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column		
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs			
21	Operate Elutriation Column	1 hr	17SS			
22	Light Phase to Resin Buffer Tank	1 hr	21SS			
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS			
24						
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank		
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF			
27	Homogenize Sludge	0.17 hrs	26			
28	Transfer Sludge to Dissolver	8 hrs	27			
29						
30	Dissolve Sludge (Batch 1)	16.67 hrs		Dissolver 1		
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs			
32	Add Initial Reagents to Dissolver	0.5 hrs	31			
33	Start Agitator	0.08 hrs	32FS-0.08 hrs			
34	Heat Dissolver Contents	2 hrs	33			
35	Releive Sludge From Sludge Buffer Tank	8 hrs	28SS			
36	Complete Reaction	4 hrs	35			
37	Cool Dissolver Contents	2 hrs	36			
38						
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	3.88 hrs		Dissolver 1		
40	Transfer 18 kg solids to Centrifuge (885 liters)	0.88 hrs	37			
41	Transfer 18 kg solids to Centrifuge (885 liters)	0.88 hrs	56			
42	Transfer Remaining Volume to Centrifuge (610 liters)	0.62 hrs	67			
43						
44	Centrifuge Dissolver Products (Batch 1)	4.71 hrs		Centrifuge		

Figure D-2 -- KE1 Process Steps for 3 Adj. Tanks & 2 Dissolver Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
45	Start Centrifuge	0.08 hrs	40SS-0.08 hrs			
46	Clarify Feed From Dissolver	0.88 hrs	40SS			
47	Transfer Liquids to Clarified Liquid Tank	0.88 hrs	46SS			
48	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	46			
49	Flush Solids Cake With Water (60 liters)	0.08 hrs	48			
50	Homogenize Solids Cake and Water	0.08 hrs	49			
51	Recentrifuge Homogenized Slurry	0.17 hrs	50			
52	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	51SS			
53	Flush Solids Cake With Water (60 liters)	0.08 hrs	52			
54	Homogenize Solids Cake and Water	0.08 hrs	53			
55	Transfer Solution to Leaching Tank	0.08 hrs	54			
56	Prepare Centrifuge for more feed	0.08 hrs	55			
57	Clarify Feed From Dissolver	0.88 hrs	41SS			
58	Transfer Liquids to Clarified Liquid Tank	0.88 hrs	57SS			
59	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	57			
60	Flush Solids Cake With Water (60 liters)	0.08 hrs	59			
61	Homogenize Solids Cake and Water	0.08 hrs	60			
62	Recentrifuge Homogenized Slurry	0.17 hrs	61			
63	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	62SS			
64	Flush Solids Cake With Water (60 liters)	0.08 hrs	63			
65	Homogenize Solids Cake and Water	0.08 hrs	64			
66	Transfer Solution to Leaching Tank	0.08 hrs	65			
67	Prepare Centrifuge for more feed	0.08 hrs	66			
68	Clarify Feed From Dissolver	0.62 hrs	42SS			
69	Transfer Liquids to Clarified Liquid Tank	0.62 hrs	68SS			
70	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	68			
71	Flush Solids Cake With Water (60 liters)	0.08 hrs	70			
72	Homogenize Solids Cake and Water	0.08 hrs	71			
73	Recentrifuge Homogenized Slurry	0.17 hrs	72			
74	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	73SS			
75	Flush Solids Cake With Water (60 liters)	0.08 hrs	74			
76	Homogenize Solids Cake and Water	0.08 hrs	75			
77	Transfer Solution to Leaching Tank	0.08 hrs	76			
78	Prepare Centrifuge for more feed	0.08 hrs	77			
79						
80	Leach Rinsed Dissolver Solids (Batch 1)	7.57 hrs		Leaching Tank		
81	Receive Centrifuged Dissolver Slurry	0.08 hrs	55SS			
82	Receive Centrifuged Dissolver Slurry	0.08 hrs	66SS			
83	Receive Centrifuged Dissolver Slurry	0.08 hrs	77SS			
84	Add Leaching Reagents	0.5 hrs	83			
85	Homogenize Slurry to Aid Leaching	4 hrs	84			
86						
87	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	2.46 hrs		Leaching Tank		
88	Transfer 18 kg solids to Centrifuge (361 liters)	0.37 hrs	85			

Figure D-2 -- KE1 Process Steps for 3 Adj. Tanks & 2 Dissolver Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	
					1	2
89	Transfer 18 kg solids to Centrifuge (361 liters)	0.37 hrs	104			
90	Transfer Remaining Volume to Centrifuge (195 liters)	0.2 hrs	115			
91						
92	Centrifuge Leached Dissolver Slurry (Batch 1)	3.31 hrs		Centrifuge		
93	Start Centrifuge	0.08 hrs	88SS-0.08 hrs			
94	Clarify Feed From Leaching Tank	0.37 hrs	88SS			
95	Transfer Liquids to Clarified Liquid Tank	0.37 hrs	94SS			
96	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	94			
97	Flush Solids Cake With Water (60 liters)	0.08 hrs	96			
98	Homogenize Solids Cake and Water	0.08 hrs	97			
99	Recentrifuge Homogenized Slurry	0.17 hrs	98			
100	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	99SS			
101	Flush Solids Cake With Water (75 liters)	0.1 hrs	100			
102	Homogenize Solids Cake and Water	0.08 hrs	101			
103	Transfer Solution to Solids Reception Tank	0.08 hrs	102			
104	Prepare Centrifuge for more feed	0.08 hrs	103			
105	Clarify Feed From Leaching Tank	0.37 hrs	89SS			
106	Transfer Liquids to Clarified Liquid Tank	0.37 hrs	105SS			
107	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	105			
108	Flush Solids Cake With Water (60 liters)	0.08 hrs	107			
109	Homogenize Solids Cake and Water	0.08 hrs	108			
110	Recentrifuge Homogenized Slurry	0.17 hrs	109			
111	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	110SS			
112	Flush Solids Cake With Water (75 liters)	0.1 hrs	111			
113	Homogenize Solids Cake and Water	0.08 hrs	112			
114	Transfer Solution to Solids Reception Tank	0.08 hrs	113			
115	Prepare Centrifuge for more feed	0.08 hrs	114			
116	Clarify Feed From Leaching Tank	0.2 hrs	90SS			
117	Transfer Liquids to Clarified Liquid Tank	0.2 hrs	116SS			
118	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	116			
119	Flush Solids Cake With Water (60 liters)	0.08 hrs	118			
120	Homogenize Solids Cake and Water	0.08 hrs	119			
121	Recentrifuge Homogenized Slurry	0.17 hrs	120			
122	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	121SS			
123	Flush Solids Cake With Water (75 liters)	0.1 hrs	122			
124	Homogenize Solids Cake and Water	0.08 hrs	123			
125	Transfer Solution to Solids Reception Tank	0.08 hrs	124			
126	Prepare Centrifuge for more feed	0.08 hrs	125			
127						
128	Store Clarified Liquid (Batch 1)	12.56 hrs		Clarified Liquid Tank		
129	Receive Clarified Dissolver Liquids From Centrifuge	0.88 hrs	47SS			
130	Receive Wash Liquids From Centrifuge	0.17 hrs	52SS			
131	Receive Clarified Dissolver Liquids From Centrifuge	0.88 hrs	58SS			
132	Receive Wash Liquids From Centrifuge	0.17 hrs	63SS			

Figure D-2 -- KE1 Process Steps for 3 Adj. Tanks & 2 Dissolver Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
133	Receive Clarified Dissolver Liquids From Centrifuge	0.62 hrs	69SS			
134	Receive Wash Liquids From Centrifuge	0.17 hrs	74SS			
135	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.37 hrs	85SS			
136	Receive Wash Liquids From Centrifuge	0.17 hrs	100SS			
137	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.37 hrs	106SS			
138	Receive Wash Liquids From Centrifuge	0.17 hrs	111SS			
139	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.2 hrs	117SS			
140	Receive Wash Liquids From Centrifuge	0.17 hrs	122SS			
141	Transfer Clarified Liquid to Cartridge Filter	0.47 hrs	140FS+0.17 hrs			
142						
143	Filter Clarified Liquid (Batch 1)	1.07 hrs		Cartridge Filter		
144	Process Clarified Liquid Through Cartridge Filter	0.47 hrs	141SS			
145	Transfer Filtered Liquid to Adjustment Tank	0.47 hrs	144SS			
146	Rinse Cartridge Filter	0.5 hrs	145			
147	Changeout Cartridge Filter	0 hrs	146FS+0.1 hrs			
148	Send Used Cartridge Filter to Final Conditioning	0 hrs	147			
149						
150	Adjust Filtered Liquid (Batch 1)	50.47 hrs		Adjustment Tank 1		
151	Receive and Store Filtered Liquid	0.97 hrs	145SS			
152	Sample and Wait For Results	48 hrs	151			
153	Add Adjustment Reagents (~2 liters)	0.25 hrs	152			
154	Homogenize Adjusted Liquid	0.25 hrs	153			
155	Transfer Adjusted Liquid to Neutralization Tank	1 hr	154			
156						
157	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank		
158	Receive and Store Adjusted Liquid	1.08 hrs	155SS			
159	Add Neutralization Reagents	1 hr	158			
160	Homogenize and Cool Neutralized Slurry	2 hrs	159			
161	Sample Slurry to Confirm TWRS Acceptability	0 hrs	160			
162	Transfer Neutralized Slurry to Transport System	1.5 hrs	161			
163						
164	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport		
165	Receive and Load Neutralized Slurry	1.5 hrs	162SS			
166	Transport Slurry to Tank Farms	8 hrs	165			
167						
168	END BATCH 1	0 hrs				
169	This marks the end of batch 1	0 hrs	166			
170						
171						
172	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank		
173	Configure Receiving Station	0.5 hrs	7SS+17 hrs			
174	Receive Sludge	1 hr	173			
175	Homogenize Feed	0.17 hrs	174			
176	Feed Screening Process	1 hr	175

Figure D-4 -- KE2 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative

ID	Task Name	Duration	Predecessors	Resource Names	
1	KE2 FEED STREAM	0 hrs			1
2	Multiple batch example with the following provisions:	0 hrs			12:
3	3 Adjustment Tanks, 2 Dissolvers	0 hrs			12:
4	18 hours between batch starts	0 hrs			12:
5					
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank	
7	Configure Receiving Station	0.5 hrs			
8	Receive Sludge	1 hr	7		
9	Homogenize Feed	0.17 hrs	8		
10	Feed Screening Process	1 hr	9		
11					
12	Screen Process Feed (Batch 1)	2 hrs		Screening System	
13	Screen Feed	1 hr	10SS		
14	Run Flush Water As Needed	1 hr	10SS		
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank	
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS		
17	Send Screened Particles to Elutriation Column	1 hr	15FF		
18					
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column	
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs		
21	Operate Elutriation Column	1 hr	17SS		
22	Light Phase to Resin Buffer Tank	1 hr	21SS		
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS		
24					
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank	
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF		
27	Homogenize Sludge	0.17 hrs	26		
28	Transfer Sludge to Dissolver	8 hrs	27		
29					
30	Dissolve Sludge (Batch 1)	28.67 hrs		Dissolver 1	
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs		
32	Add Initial Reagents to Dissolver	0.5 hrs	31		
33	Start Agitator	0.08 hrs	32FS-0.08 hrs		
34	Heat Dissolver Contents	2 hrs	33		
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS		
36	Complete Reaction	16 hrs	35		
37	Cool Dissolver Contents	2 hrs	36		
38					
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.45 hrs		Dissolver 1	
40	Transfer 11.6 kg solids to Centrifuge (2451 liters)	2.45 hrs	37		

Figure D-4 -- KE2 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
41				
42	Centrifuge Dissolver Products (Batch 1)	3.28 hrs		Centrifuge
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs	
44	Clarify Feed From Dissolver	2.45 hrs	40SS	
45	Transfer Liquids to Clarified Liquid Tank	2.45 hrs	44SS	
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44	
47	Flush Solids Cake With Water (60 liters)	0.08 hrs	46	
48	Homogenize Solids Cake and Water	0.08 hrs	47	
49	Recentrifuge Homogenized Slurry	0.17 hrs	48	
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS	
51	Flush Solids Cake With Water (60 liters)	0.08 hrs	50	
52	Homogenize Solids Cake and Water	0.08 hrs	51	
53	Transfer Solution to Leaching Tank	0.08 hrs	52	
54	Prepare Centrifuge for more feed	0.08 hrs	53	
55				
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS	
58	Add Leaching Reagents	0.5 hrs	57	
59	Homogenize Slurry to Aid Leaching	4 hrs	58	
60				
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.22 hrs		Leaching Tank
62	Transfer 10.9 kg solids to Centrifuge (218 liters)	0.22 hrs	59	
63				
64	Centrifuge Leached Dissolver Slurry (Batch 1)	1.07 hrs		Centrifuge
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs	
66	Clarify Feed From Leaching Tank	0.22 hrs	62SS	
67	Transfer Liquids to Clarified Liquid Tank	0.22 hrs	66SS	
68	Stop Centrifuge When Clarification Complete	0.08 hrs	66	
69	Flush Solids Cake With Water (60 liters)	0.08 hrs	68	
70	Homogenize Solids Cake and Water	0.08 hrs	69	
71	Recentrifuge Homogenized Slurry	0.17 hrs	70	
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS	
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72	
74	Homogenize Solids Cake and Water	0.08 hrs	73	
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74	
76	Prepare Centrifuge for more feed	0.08 hrs	75	
77				
78	Store Clarified Liquid (Batch 1)	8.78 hrs		Clarified Liquid Tank
79	Receive Clarified Dissolver Liquids From Centrifuge	2.45 hrs	45SS	
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS	

Figure D-4 -- KE2 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.22 hrs	67SS	
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS	
83	Transfer Clarified Liquid to Cartridge Filter	0.36 hrs	82FS+0.17 hrs	
84				
85	Filter Clarified Liquid (Batch 1)	0.96 hrs		Cartridge Filter
86	Process Clarified Liquid Through Cartridge Filter	0.36 hrs	83SS	
87	Transfer Filtered Liquid to Adjustment Tank	0.36 hrs	86SS	
88	Rinse Cartridge Filter	0.5 hrs	87	
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs	
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89	
91				
92	Adjust Filtered Liquid (Batch 1)	50.9 hrs		Adjustment Tank 1
93	Receive and Store Filtered Liquid	0.86 hrs	87SS	
94	Sample and Wait For Results	48 hrs	93	
95	Add Adjustment Reagents (~1010 liters)	0.79 hrs	94	
96	Homogenize Adjusted Liquid	0.25 hrs	95	
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96	
98				
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS	
101	Add Neutralization Reagents	1 hr	100	
102	Homogenize and Cool Neutralized Slurry	2 hrs	101	
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102	
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103	
105				
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS	
108	Transport Slurry to Tank Farms	8 hrs	107	
109				
110	END BATCH 1	0 hrs		
111	This marks the end of batch 1	0 hrs	108	
112				
113				
114	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank
115	Configure Receiving Station	0.5 hrs	7SS+18 hrs	
116	Receive Sludge	1 hr	115	
117	Homogenize Feed	0.17 hrs	116	
118	Feed Screening Process	1 hr	117	
119				
120	Screen Process Feed (Batch 2)	2 hrs		Screening System

Figure D-6 -- KW1 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1	2
1	KW1 FEED STREAM	0 hrs			12:00 AM	
2	Multiple batch example with the following provisions:	0 hrs			12:00 AM	
3	3 Adjustment Tanks, 2 Dissolvers	0 hrs			12:00 AM	
4	19 hours between batch starts	0 hrs			12:00 AM	
5						
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank		
7	Configure Receiving Station	0.5 hrs				
8	Receive Sludge	1 hr	7			
9	Homogenize Feed	0.17 hrs	8			
10	Feed Screening Process	1 hr	9			
11						
12	Screen Process Feed (Batch 1)	2 hrs		Screening System		
13	Screen Feed	1 hr	10SS			
14	Run Flush Water As Needed	1 hr	10SS			
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank		
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS			
17	Send Screened Particles to Elutriation Column	1 hr	15FF			
18						
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column		
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs			
21	Operate Elutriation Column	1 hr	17SS			
22	Light Phase to Resin Buffer Tank	1 hr	21SS			
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS			
24						
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank		
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF			
27	Homogenize Sludge	0.17 hrs	26			
28	Transfer Sludge to Dissolver	8 hrs	27			
29						
30	Dissolve Sludge (Batch 1)	14.67 hrs		Dissolver 1		
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs			
32	Add Initial Reagents to Dissolver	0.5 hrs	31			
33	Start Agitator	0.08 hrs	32FS-0.08 hrs			
34	Heat Dissolver Contents	2 hrs	33			
35	Recieve Sludge From Sludge Buffer Tank	8 hrs	28SS			
36	Complete Reaction	2 hrs	35			
37	Cool Dissolver Contents	2 hrs	36			
38						
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	5.99 hrs		Dissolver 1		
40	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	37			
41	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	59			
42	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	70			
43	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	81			
44	Transfer 18 kg solids to Centrifuge (372 liters)	0.38 hrs	92			

Figure D-6 -- KW1 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1		2
					1	2	
45	Transfer Remaining Volume to Centrifuge (355 liters)	0.36 hrs	103				
46							
47	Centrifuge Dissolver Products (Batch 1)	6.82 hrs		Centrifuge			
48	Start Centrifuge	0.08 hrs	40SS-0.08 hrs				
49	Clarify Feed From Dissolver	0.38 hrs	40SS				
50	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	49SS				
51	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	49				
52	Flush Solids Cake With Water (60 liters)	0.08 hrs	51				
53	Homogenize Solids Cake and Water	0.08 hrs	52				
54	Recentrifuge Homogenized Slurry	0.17 hrs	53				
55	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	54SS				
56	Flush Solids Cake With Water (60 liters)	0.08 hrs	55				
57	Homogenize Solids Cake and Water	0.08 hrs	56				
58	Transfer Solution to Leaching Tank	0.08 hrs	57				
59	Prepare Centrifuge for more feed	0.08 hrs	58				
60	Clarify Feed From Dissolver	0.38 hrs	41SS				
61	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	60SS				
62	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	60				
63	Flush Solids Cake With Water (60 liters)	0.08 hrs	62				
64	Homogenize Solids Cake and Water	0.08 hrs	63				
65	Recentrifuge Homogenized Slurry	0.17 hrs	64				
66	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	65SS				
67	Flush Solids Cake With Water (60 liters)	0.08 hrs	66				
68	Homogenize Solids Cake and Water	0.08 hrs	67				
69	Transfer Solution to Leaching Tank	0.08 hrs	68				
70	Prepare Centrifuge for more feed	0.08 hrs	69				
71	Clarify Feed From Dissolver	0.38 hrs	42SS				
72	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	71SS				
73	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	71				
74	Flush Solids Cake With Water (60 liters)	0.08 hrs	73				
75	Homogenize Solids Cake and Water	0.08 hrs	74				
76	Recentrifuge Homogenized Slurry	0.17 hrs	75				
77	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	76SS				
78	Flush Solids Cake With Water (60 liters)	0.08 hrs	77				
79	Homogenize Solids Cake and Water	0.08 hrs	78				
80	Transfer Solution to Leaching Tank	0.08 hrs	79				
81	Prepare Centrifuge for more feed	0.08 hrs	80				
82	Clarify Feed From Dissolver	0.38 hrs	43SS				
83	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	82SS				
84	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	82				
85	Flush Solids Cake With Water (60 liters)	0.08 hrs	84				
86	Homogenize Solids Cake and Water	0.08 hrs	85				
87	Recentrifuge Homogenized Slurry	0.17 hrs	86				
88	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	87SS				

Figure D-6 -- KW1 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
89	Flush Solids Cake With Water (60 liters)	0.08 hrs	88			
90	Homogenize Solids Cake and Water	0.08 hrs	89			
91	Transfer Solution to Leaching Tank	0.08 hrs	90			
92	Prepare Centrifuge for more feed	0.08 hrs	91			
93	Clarify Feed From Dissolver	0.38 hrs	44SS			
94	Transfer Liquids to Clarified Liquid Tank	0.38 hrs	93SS			
95	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	93			
96	Flush Solids Cake With Water (60 liters)	0.08 hrs	95			
97	Homogenize Solids Cake and Water	0.08 hrs	96			
98	Recentrifuge Homogenized Slurry	0.17 hrs	97			
99	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	98SS			
100	Flush Solids Cake With Water (60 liters)	0.08 hrs	99			
101	Homogenize Solids Cake and Water	0.08 hrs	100			
102	Transfer Solution to Leaching Tank	0.08 hrs	101			
103	Prepare Centrifuge for more feed	0.08 hrs	102			
104	Clarify Feed From Dissolver	0.36 hrs	45SS			
105	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	104SS			
106	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	104			
107	Flush Solids Cake With Water (60 liters)	0.08 hrs	106			
108	Homogenize Solids Cake and Water	0.08 hrs	107			
109	Recentrifuge Homogenized Slurry	0.17 hrs	108			
110	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	109SS			
111	Flush Solids Cake With Water (60 liters)	0.08 hrs	110			
112	Homogenize Solids Cake and Water	0.08 hrs	111			
113	Transfer Solution to Leaching Tank	0.08 hrs	112			
114	Prepare Centrifuge for more feed	0.08 hrs	113			
115						
116	Leach Rinsed Dissolver Solids (Batch 1)	10.19 hrs		Leaching Tank		
117	Receive Centrifuged Dissolver Slurry	0.08 hrs	58SS			
118	Receive Centrifuged Dissolver Slurry	0.08 hrs	69SS			
119	Receive Centrifuged Dissolver Slurry	0.08 hrs	80SS			
120	Receive Centrifuged Dissolver Slurry	0.08 hrs	91SS			
121	Receive Centrifuged Dissolver Slurry	0.08 hrs	102SS			
122	Receive Centrifuged Dissolver Slurry	0.08 hrs	113SS			
123	Add Leaching Reagents	0.5 hrs	122			
124	Homogenize Slurry to Aid Leaching	4 hrs	123			
125						
126	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	5.85 hrs		Leaching Tank		
127	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	124			
128	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	146			
129	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	157			
130	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	168			
131	Transfer 18 kg solids to Centrifuge (360 liters)	0.36 hrs	179			
132	Transfer Remaining Volume to Centrifuge (228 liters)	0.23 hrs	190			

Figure D-6 -- KW1 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1	2
133						
134	Centrifuge Leached Dissolver Slurry (Batch 1)	6.69 hrs		Centrifuge		
135	Start Centrifuge	0.08 hrs	127SS-0.08 hrs			
136	Clarify Feed From Leaching Tank	0.36 hrs	127SS			
137	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	136SS			
138	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	136			
139	Flush Solids Cake With Water (60 liters)	0.08 hrs	138			
140	Homogenize Solids Cake and Water	0.08 hrs	139			
141	Recentrifuge Homogenized Slurry	0.17 hrs	140			
142	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	141SS			
143	Flush Solids Cake With Water (75 liters)	0.1 hrs	142			
144	Homogenize Solids Cake and Water	0.08 hrs	143			
145	Transfer Solution to Solids Reception Tank	0.08 hrs	144			
146	Prepare Centrifuge for more feed	0.08 hrs	145			
147	Clarify Feed From Leaching Tank	0.36 hrs	128SS			
148	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	147SS			
149	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	147			
150	Flush Solids Cake With Water (60 liters)	0.08 hrs	149			
151	Homogenize Solids Cake and Water	0.08 hrs	150			
152	Recentrifuge Homogenized Slurry	0.17 hrs	151			
153	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	152SS			
154	Flush Solids Cake With Water (75 liters)	0.1 hrs	153			
155	Homogenize Solids Cake and Water	0.08 hrs	154			
156	Transfer Solution to Solids Reception Tank	0.08 hrs	155			
157	Prepare Centrifuge for more feed	0.08 hrs	156			
158	Clarify Feed From Leaching Tank	0.36 hrs	129SS			
159	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	158SS			
160	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	158			
161	Flush Solids Cake With Water (60 liters)	0.08 hrs	160			
162	Homogenize Solids Cake and Water	0.08 hrs	161			
163	Recentrifuge Homogenized Slurry	0.17 hrs	162			
164	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	163SS			
165	Flush Solids Cake With Water (75 liters)	0.1 hrs	164			
166	Homogenize Solids Cake and Water	0.08 hrs	165			
167	Transfer Solution to Solids Reception Tank	0.08 hrs	166			
168	Prepare Centrifuge for more feed	0.08 hrs	167			
169	Clarify Feed From Leaching Tank	0.36 hrs	130SS			
170	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	168SS			
171	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	169			
172	Flush Solids Cake With Water (60 liters)	0.08 hrs	171			
173	Homogenize Solids Cake and Water	0.08 hrs	172			
174	Recentrifuge Homogenized Slurry	0.17 hrs	173			
175	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	174SS			
176	Flush Solids Cake With Water (75 liters)	0.1 hrs	175			

Figure D-6 -- KW1 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
177	Homogenize Solids Cake and Water	0.08 hrs	176			
178	Transfer Solution to Solids Reception Tank	0.08 hrs	177			
179	Prepare Centrifuge for more feed	0.08 hrs	178			
180	Clarify Feed From Leaching Tank	0.36 hrs	131SS			
181	Transfer Liquids to Clarified Liquid Tank	0.36 hrs	180SS			
182	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	180			
183	Flush Solids Cake With Water (60 liters)	0.08 hrs	182			
184	Homogenize Solids Cake and Water	0.08 hrs	183			
185	Recentrifuge Homogenized Slurry	0.17 hrs	184			
186	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	185SS			
187	Flush Solids Cake With Water (75 liters)	0.1 hrs	186			
188	Homogenize Solids Cake and Water	0.08 hrs	187			
189	Transfer Solution to Solids Reception Tank	0.08 hrs	188			
190	Prepare Centrifuge for more feed	0.08 hrs	189			
191	Clarify Feed From Leaching Tank	0.23 hrs	132SS			
192	Transfer Liquids to Clarified Liquid Tank	0.23 hrs	191SS			
193	Stop Centrifuge When 18 kg of solids retained	0.08 hrs	191			
194	Flush Solids Cake With Water (60 liters)	0.08 hrs	193			
195	Homogenize Solids Cake and Water	0.08 hrs	194			
196	Recentrifuge Homogenized Slurry	0.17 hrs	195			
197	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	196SS			
198	Flush Solids Cake With Water (75 liters)	0.1 hrs	197			
199	Homogenize Solids Cake and Water	0.08 hrs	198			
200	Transfer Solution to Solids Reception Tank	0.08 hrs	199			
201	Prepare Centrifuge for more feed	0.08 hrs	200			
202						
203	Store Clarified Liquid (Batch 1)	18.2 hrs		Clarified Liquid Tank		
204	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	50SS			
205	Receive Wash Liquids From Centrifuge	0.17 hrs	55SS			
206	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	61SS			
207	Receive Wash Liquids From Centrifuge	0.17 hrs	66SS			
208	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	72SS			
209	Receive Wash Liquids From Centrifuge	0.17 hrs	77SS			
210	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	83SS			
211	Receive Wash Liquids From Centrifuge	0.17 hrs	88SS			
212	Receive Clarified Dissolver Liquids From Centrifuge	0.38 hrs	94SS			
213	Receive Wash Liquids From Centrifuge	0.17 hrs	99SS			
214	Receive Clarified Dissolver Liquids From Centrifuge	0.36 hrs	105SS			
215	Receive Wash Liquids From Centrifuge	0.17 hrs	110SS			
216	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	137SS			
217	Receive Wash Liquids From Centrifuge	0.17 hrs	142SS			
218	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	148SS			
219	Receive Wash Liquids From Centrifuge	0.17 hrs	153SS			
220	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	159SS			

Figure D-6 -- KW1 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names		
					1	2
221	Receive Wash Liquids From Centrifuge	0.17 hrs	164SS			
222	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	170SS			
223	Receive Wash Liquids From Centrifuge	0.17 hrs	175SS			
224	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.36 hrs	181SS			
225	Receive Wash Liquids From Centrifuge	0.17 hrs	186SS			
226	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.23 hrs	192SS			
227	Receive Wash Liquids From Centrifuge	0.17 hrs	197SS			
228	Transfer Clarified Liquid to Cartridge Filter	0.61 hrs	227FS+0.17 hrs			
229						
230	Filter Clarified Liquid (Batch 1)	1.21 hrs		Cartridge Filter		
231	Process Clarified Liquid Through Cartridge Filter	0.61 hrs	228SS			
232	Transfer Filtered Liquid to Adjustment Tank	0.61 hrs	231SS			
233	Rinse Cartridge Filter	0.5 hrs	232			
234	Changeout Cartridge Filter	0 hrs	233FS+0.1 hrs			
235	Send Used Cartridge Filter to Final Conditioning	0 hrs	234			
236						
237	Adjust Filtered Liquid (Batch 1)	50.61 hrs		Adjustment Tank 1		
238	Receive and Store Filtered Liquid	1.11 hrs	232SS			
239	Sample and Wait For Results	48 hrs	238			
240	Add Adjustment Reagents (~1 liters)	0.25 hrs	239			
241	Homogenize Adjusted Liquid	0.25 hrs	240			
242	Transfer Adjusted Liquid to Neutralization Tank	1 hr	241			
243						
244	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank		
245	Receive and Store Adjusted Liquid	1.08 hrs	242SS			
246	Add Neutralization Reagents	1 hr	245			
247	Homogenize and Cool Neutralized Slurry	2 hrs	246			
248	Sample Slurry to Confirm TWRS Acceptability	0 hrs	247			
249	Transfer Neutralized Slurry to Transport System	1.5 hrs	248			
250						
251	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport		
252	Receive and Load Neutralized Slurry	1.5 hrs	249SS			
253	Transport Slurry to Tank Farms	8 hrs	252			
254						
255	END BATCH 1	0 hrs				
256	This marks the end of batch 1	0 hrs	253			
257						
258						
259	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank		
260	Configure Receiving Station	0.5 hrs	75S+19 hrs			
261	Receive Sludge	1 hr	260			
262	Homogenize Feed	0.17 hrs	261			
263	Feed Screening Process	1 hr	262			
264						

Figure D-8 -- KW2 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1
1	KW2 FEED STREAM	0 hrs			12:00 A
2	Multiple batch example with the following provisions:	0 hrs			12:00 A
3	3 Adjustment Tanks, 2 Dissolvers	0 hrs			12:00 A
4	18 hours between batch starts	0 hrs			12:00 A
5					
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank	
7	Configure Receiving Station	0.5 hrs			
8	Receive Sludge	1 hr	7		
9	Homogenize Feed	0.17 hrs	8		
10	Feed Screening Process	1 hr	9		
11					
12	Screen Process Feed (Batch 1)	2 hrs		Screening System	
13	Screen Feed	1 hr	10SS		
14	Run Flush Water As Needed	1 hr	10SS		
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank	
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS		
17	Send Screened Particles to Elutriation Column	1 hr	15FF		
18					
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column	
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs		
21	Operate Elutriation Column	1 hr	17SS		
22	Light Phase to Resin Buffer Tank	1 hr	21SS		
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS		
24					
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank	
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF		
27	Homogenize Sludge	0.17 hrs	26		
28	Transfer Sludge to Dissolver	8 hrs	27		
29					
30	Dissolve Sludge (Batch 1)	32.67 hrs		Dissolver 1	
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs		
32	Add Initial Reagents to Dissolver	0.5 hrs	31		
33	Start Agitator	0.08 hrs	32FS-0.08 hrs		
34	Heat Dissolver Contents	2 hrs	33		
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS		
36	Complete Reaction	20 hrs	35		
37	Cool Dissolver Contents	2 hrs	36		
38					
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.44 hrs		Dissolver 1	
40	Transfer 12.9 kg solids to Centrifuge (2441 liters)	2.44 hrs	37		
41					

Figure D-8 -- KW2 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
42	Centrifuge Dissolver Products (Batch 1)	3.27 hrs		Centrifuge	
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs		
44	Clarify Feed From Dissolver	2.44 hrs	40SS		
45	Transfer Liquids to Clarified Liquid Tank	2.44 hrs	44SS		
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44		
47	Flush Solids Cake With Water (60 liters)	0.08 hrs	46		
48	Homogenize Solids Cake and Water	0.08 hrs	47		
49	Recentrifuge Homogenized Slurry	0.17 hrs	48		
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS		
51	Flush Solids Cake With Water (60 liters)	0.08 hrs	50		
52	Homogenize Solids Cake and Water	0.08 hrs	51		
53	Transfer Solution to Leaching Tank	0.08 hrs	52		
54	Prepare Centrifuge for more feed	0.08 hrs	53		
55					
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank	
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS		
58	Add Leaching Reagents	0.5 hrs	57		
59	Homogenize Slurry to Aid Leaching	4 hrs	58		
60					
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.25 hrs		Leaching Tank	
62	Transfer 12.2 kg solids to Centrifuge (245 liters)	0.25 hrs	59		
63					
64	Centrifuge Leached Dissolver Slurry (Batch 1)	1.1 hrs		Centrifuge	
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs		
66	Clarify Feed From Leaching Tank	0.25 hrs	62SS		
67	Transfer Liquids to Clarified Liquid Tank	0.25 hrs	66SS		
68	Stop Centrifuge When Clarification Complete	0.08 hrs	66		
69	Flush Solids Cake With Water (60 liters)	0.08 hrs	68		
70	Homogenize Solids Cake and Water	0.08 hrs	69		
71	Recentrifuge Homogenized Slurry	0.17 hrs	70		
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS		
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72		
74	Homogenize Solids Cake and Water	0.08 hrs	73		
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74		
76	Prepare Centrifuge for more feed	0.08 hrs	75		
77					
78	Store Clarified Liquid (Batch 1)	8.81 hrs		Clarified Liquid Tank	
79	Receive Clarified Dissolver Liquids From Centrifuge	2.44 hrs	45SS		
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS		
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.25 hrs	67SS		
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS		

Figure D-8 -- KW2 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
83	Transfer Clarified Liquid to Cartridge Filter	0.37 hrs	82FS+0.17 hrs		
84					
85	Filter Clarified Liquid (Batch 1)	0.97 hrs		Cartridge Filter	
86	Process Clarified Liquid Through Cartridge Filter	0.37 hrs	83SS		
87	Transfer Filtered Liquid to Adjustment Tank	0.37 hrs	86SS		
88	Rinse Cartridge Filter	0.5 hrs	87		
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs		
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89		
91					
92	Adjust Filtered Liquid (Batch 1)	51.12 hrs		Adjustment Tank 1	
93	Receive and Store Filtered Liquid	0.87 hrs	87SS		
94	Sample and Wait For Results	48 hrs	93		
95	Add Adjustment Reagents (~1279 liters)	1 hr	94		
96	Homogenize Adjusted Liquid	0.25 hrs	95		
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96		
98					
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank	
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS		
101	Add Neutralization Reagents	1 hr	100		
102	Homogenize and Cool Neutralized Slurry	2 hrs	101		
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102		
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103		
105					
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport	
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS		
108	Transport Slurry to Tank Farms	8 hrs	107		
109					
110	END BATCH 1	0 hrs			
111	This marks the end of batch 1	0 hrs	108		
112					
113					
114	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank	
115	Configure Receiving Station	0.5 hrs	7SS+18 hrs		
116	Receive Sludge	1 hr	115		
117	Homogenize Feed	0.17 hrs	116		
118	Feed Screening Process	1 hr	117		
119					
120	Screen Process Feed (Batch 2)	2 hrs		Screening System	
121	Screen Feed	1 hr	118SS		
122	Run Flush Water As Needed	1 hr	118SS		
123	Store and homogenize screened particles	2 hrs	118SS	Interim Holding Tank	

Figure D-10 -- KW3 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative

ID	Task Name	Duration	Predecessors	Resource Names	1
1	KW3 FEED STREAM	0 hrs			12:
2	Multiple batch example with the following provisions:	0 hrs			12:0
3	3 Adjustment Tanks, 2 Dissolvers	0 hrs			12:0
4	17 hours between batch starts	0 hrs			12:0
5					
6	Store Process Feed (Batch 1)	2.67 hrs		Lag Storage Tank	
7	Configure Receiving Station	0.5 hrs			
8	Receive Sludge	1 hr	7		
9	Homogenize Feed	0.17 hrs	8		
10	Feed Screening Process	1 hr	9		
11					
12	Screen Process Feed (Batch 1)	2 hrs		Screening System	
13	Screen Feed	1 hr	10SS		
14	Run Flush Water As Needed	1 hr	10SS		
15	Store and homogenize screened particles	2 hrs	10SS	Interim Holding Tank	
16	Send Sludge to Sludge Buffer Tank	1 hr	10SS		
17	Send Screened Particles to Elutriation Column	1 hr	15FF		
18					
19	Elutriate Resins (Batch 1)	1.7 hrs		Elutriation Column	
20	Start Elutriation Column	0.2 hrs	17SS-0.2 hrs		
21	Operate Elutriation Column	1 hr	17SS		
22	Light Phase to Resin Buffer Tank	1 hr	21SS		
23	Heavy Phase to Sludge Buffer Tank	1.5 hrs	21SS		
24					
25	Store Sludge (Batch 1)	10.67 hrs		Sludge Buffer Tank	
26	Receive Sludge From Screening/Elutriation	2.5 hrs	16SS,23FF		
27	Homogenize Sludge	0.17 hrs	26		
28	Transfer Sludge to Dissolver	8 hrs	27		
29					
30	Dissolve Sludge (Batch 1)	24.67 hrs		Dissolver 1	
31	Receive Recycled Nitric Acid	0.17 hrs	28SS-2.67 hrs		
32	Add Initial Reagents to Dissolver	0.5 hrs	31		
33	Start Agitator	0.08 hrs	32FS-0.08 hrs		
34	Heat Dissolver Contents	2 hrs	33		
35	Receive Sludge From Sludge Buffer Tank	8 hrs	28SS		
36	Complete Reaction	12 hrs	35		
37	Cool Dissolver Contents	2 hrs	36		
38					
39	Transfer Dissolver Contents to Centrifuge (Batch 1)	2.44 hrs		Dissolver 1	
40	Transfer 5.63 kg solids to Centrifuge (2438 liters)	2.44 hrs	37		

Figure D-10 -- KW3 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
41					
42	Centrifuge Dissolver Products (Batch 1)	3.27 hrs		Centrifuge	
43	Start Centrifuge	0.08 hrs	40SS-0.08 hrs		
44	Clarify Feed From Dissolver	2.44 hrs	40SS		
45	Transfer Liquids to Clarified Liquid Tank	2.44 hrs	44SS		
46	Stop Centrifuge When Clarification Complete	0.08 hrs	44		
47	Flush Solids Cake With Water (60 liters)	0.08 hrs	46		
48	Homogenize Solids Cake and Water	0.08 hrs	47		
49	Recentrifuge Homogenized Slurry	0.17 hrs	48		
50	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	49SS		
51	Flush Solids Cake With Water (60 liters)	0.08 hrs	50		
52	Homogenize Solids Cake and Water	0.08 hrs	51		
53	Transfer Solution to Leaching Tank	0.08 hrs	52		
54	Prepare Centrifuge for more feed	0.08 hrs	53		
55					
56	Leach Rinsed Dissolver Solids (Batch 1)	4.58 hrs		Leaching Tank	
57	Receive Centrifuged Dissolver Slurry	0.08 hrs	53SS		
58	Add Leaching Reagents	0.5 hrs	57		
59	Homogenize Slurry to Aid Leaching	4 hrs	58		
60					
61	Transfer Leached Dissolver Slurry to Centrifuge (Batch 1)	0.11 hrs		Leaching Tank	
62	Transfer 5.3 kg solids to Centrifuge (107 liters)	0.11 hrs	59		
63					
64	Centrifuge Leached Dissolver Slurry (Batch 1)	0.96 hrs		Centrifuge	
65	Start Centrifuge	0.08 hrs	62SS-0.08 hrs		
66	Clarify Feed From Leaching Tank	0.11 hrs	62SS		
67	Transfer Liquids to Clarified Liquid Tank	0.11 hrs	66SS		
68	Stop Centrifuge When Clarification Complete	0.08 hrs	66		
69	Flush Solids Cake With Water (60 liters)	0.08 hrs	68		
70	Homogenize Solids Cake and Water	0.08 hrs	69		
71	Recentrifuge Homogenized Slurry	0.17 hrs	70		
72	Transfer Liquids to Clarified Liquid Tank	0.17 hrs	71SS		
73	Flush Solids Cake With Water (75 liters)	0.1 hrs	72		
74	Homogenize Solids Cake and Water	0.08 hrs	73		
75	Transfer Solution to Solids Reception Tank	0.08 hrs	74		
76	Prepare Centrifuge for more feed	0.08 hrs	75		
77					
78	Store Clarified Liquid (Batch 1)	8.63 hrs		Clarified Liquid Tank	
79	Receive Clarified Dissolver Liquids From Centrifuge	2.44 hrs	45SS		
80	Receive Wash Liquids From Centrifuge	0.17 hrs	50SS		

Figure D-10 -- KW3 Process Steps for 3 Adj. Tanks & 2 Dissolvers Alternative (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
81	Receive Clarified Leached Dissolver Slurry Liquids From Centrifuge	0.11 hrs	67SS		
82	Receive Wash Liquids From Centrifuge	0.17 hrs	72SS		
83	Transfer Clarified Liquid to Cartridge Filter	0.33 hrs	82FS+0.17 hrs		
84					
85	Filter Clarified Liquid (Batch 1)	0.93 hrs		Cartridge Filter	
86	Process Clarified Liquid Through Cartridge Filter	0.33 hrs	83SS		
87	Transfer Filtered Liquid to Adjustment Tank	0.33 hrs	86SS		
88	Rinse Cartridge Filter	0.5 hrs	87		
89	Changeout Cartridge Filter	0 hrs	88FS+0.1 hrs		
90	Send Used Cartridge Filter to Final Conditioning	0 hrs	89		
91					
92	Adjust Filtered Liquid (Batch 1)	50.96 hrs		Adjustment Tank 1	
93	Receive and Store Filtered Liquid	0.83 hrs	87SS		
94	Sample and Wait For Results	48 hrs	93		
95	Add Adjustment Reagents (~1121 liters)	0.88 hrs	94		
96	Homogenize Adjusted Liquid	0.25 hrs	95		
97	Transfer Adjusted Liquid to Neutralization Tank	1 hr	96		
98					
99	Neutralize Adjusted Liquid (Batch 1)	5.58 hrs		Neutralization Tank	
100	Receive and Store Adjusted Liquid	1.08 hrs	97SS		
101	Add Neutralization Reagents	1 hr	100		
102	Homogenize and Cool Neutralized Slurry	2 hrs	101		
103	Sample Slurry to Confirm TWRS Acceptability	0 hrs	102		
104	Transfer Neutralized Slurry to Transport System	1.5 hrs	103		
105					
106	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport	
107	Receive and Load Neutralized Slurry	1.5 hrs	104SS		
108	Transport Slurry to Tank Farms	8 hrs	107		
109					
110	END BATCH 1	0 hrs			
111	This marks the end of batch 1	0 hrs	108		
112					
113					
114	Store Process Feed (Batch 2)	2.67 hrs		Lag Storage Tank	
115	Configure Receiving Station	0.5 hrs	7SS+17 hrs		
116	Receive Sludge	1 hr	115		
117	Homogenize Feed	0.17 hrs	116		
118	Feed Screening Process	1 hr	117		
119					
120	Screen Process Feed (Batch 2)	2 hrs		Screening System	

Figure D-11– Excel Spreadsheet Calculation Display

3 Adjustment Tank and 2 Dissolver Alternative								
	KE1	KE2	KW1	KW2	KW3			
Hours between batch starts	17	18	19	18	17			
Hours to get batch completely into adjustment tank	32	40	36	44	36			
Hours until batch is out of adjustment tank	81	90	85	94	86			
Hours beginning to end for one batch	93	103	98	107	99			
Total Processing Hours Added by Resin Processing	278	13	0	0	15			
Total Batches for feed stream	146.1	24.4	11.2	10.2	22.4			
The following numbers are derived starting with the equation $(n-1) \times (\text{time between batch starts}) = \text{start of batch } n$								
All values are in hours, and assumes a cleaning every 10 batches unless otherwise stated.								
	Batch 10 start	Cleaning Start	Batch 11 Start	Batch 11 Start without cleaning	Time added per batch by cleaning	New Batch Start Equivalent	End Time of Final Batch	End Time of Final Batch Without Cleaning
KE1	153	201	225	189	3.6	20.6	3360.1	2837.7
KE2	162	202	226	180	4.6	22.6	644.8	537.2
KW1	171	207	231	190	4.1	23.1	333.6	291.8
KW2	162	206	230	180	5.0	23.0	318.6	272.6
KW3	153	189	213	170	4.3	21.3	569.8	477.8
	Time to Process Stream with Cleaning (Days)	Time to Process Stream without Cleaning (Days)						
KE1	140.0	118.2						
KE2	26.9	22.4						
KW1	13.9	12.2						
KW2	13.3	11.4						
KW3	23.7	19.9						
Total	217.8	184.0						

APPENDIX E

SUPPORT INFORMATION AND CALCULATION RESULTS FOR GROUTING

The summary process steps from the Microsoft Project model for grouting treated solids were shown previously in Figure 5-1. Figure 5-1 was directly used to estimate the time required for grouting treating solids. The detailed process steps supporting Figure 5-1 can be found in Figure E-1. There were no other calculations performed for this piece of the process.

Figure E-1 -- Detailed Process Steps for Grouting Treated Solids

ID	Task Name	Duration	Predecessors	Resource Names	1
1	Grout Treated Solids	0 hrs			12:00
2	Assume 3 Adjustment Tanks Available	0 hrs			12:00 A
3					
4	Treat Excess Liquid	0 hrs			12:00
5	Assume this can be done in 6 equal batches	0 hrs			12:00 A
6					
7	Settle Leached/Flushed Slurry	120 hrs		Solids Reception Tank	
8	Receive All Slurry Before Starting (52,127 Liters)	0 hrs			12:00 A
9	Settle Solids in Solids Reception Tank	5 days	8		
10					
11	Decant and Transfer Excess Liquid	101 hrs		Solids Reception Tank	
12	Transfer Excess Liquid Batch 1 (5,527 liters)	1 hr	9		
13	Transfer Excess Liquid Batch 2 (5,527 liters)	1 hr	12SS+20 hrs		
14	Transfer Excess Liquid Batch 3 (5,527 liters)	1 hr	13SS+20 hrs		
15	Transfer Excess Liquid Batch 4 (5,527 liters)	1 hr	14SS+20 hrs		
16	Transfer Excess Liquid Batch 5 (5,527 liters)	1 hr	15SS+20 hrs		
17	Transfer Excess Liquid Batch 6 (5,527 liters)	1 hr	16SS+20 hrs		
18					
19	Store Excess Liquid (Batch 1)	1.62 hrs		Clarified Liquid Tank	
20	Receive Excess Liquid (5,527 liters)	1 hr	12SS		
21	Transfer Excess Liquid to Cartridge Filter	0.62 hrs	20		
22					
23	Filter Excess Liquid (Batch 1)	0.62 hrs		Cartridge Filter	
24	Process Excess Liquid Through Cartridge Filter	0.62 hrs	21SS		
25	Transfer Filtered Liquid to Adjustment Tank	0.62 hrs	24SS		
26	Rinse Cartridge Filter	0 hrs	25		
27	Changeout Cartridge Filter	0 hrs	26		
28	Send Used Cartridge Filter to Final Conditioning	0 hrs	27		
29					
30	Adjust Filtered Liquid (Batch 1)	49.87 hrs		Adjustment Tank 1	
31	Receive and Store Filtered Liquid	0.62 hrs	25SS		
32	Sample and Wait For Results	48 hrs	31		
33	Add Adjustment Reagents (< 1 liter/batch)	0 hrs	32		
34	Homogenize Adjusted Liquid	0.25 hrs	33		
35	Transfer Adjusted Liquid to Neutralization Tank	1 hr	34		
36					
37	Neutralize Adjusted Liquid (Batch 1)	3.33 hrs		Neutralization Tank	
38	Receive and Store Adjusted Liquid	1.08 hrs	35SS		
39	Add Neutralization Reagents (~16 liters/batch)	0.25 hrs	38		
40	Homogenize and Cool Neutralized Slurry	0.5 hrs	39		
41	Sample Slurry to Confirm TWRS Acceptability	0 hrs	40		
42	Transfer Neutralized Slurry to Transport System	1.5 hrs	41		

Figure E-1 -- Detailed Process Steps for Grouting Treated Solids (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
43					
44	Transport Neutralized Slurry to TWRS (Batch 1)	9.5 hrs		TWRS Transport	
45	Receive and Load Neutralized Slurry	1.5 hrs	42SS		
46	Transport Slurry to Tank Farms	8 hrs	45		
47					
48	Store Excess Liquid (Batch 2)	1.62 hrs		Clarified Liquid Tank	
49	Receive Excess Liquid (5,527 liters)	1 hr	13SS		
50	Transfer Excess Liquid to Cartridge Filter	0.62 hrs	49		
51					
52	Filter Excess Liquid (Batch 2)	0.62 hrs		Cartridge Filter	
53	Process Excess Liquid Through Cartridge Filter	0.62 hrs	50SS		
54	Transfer Filtered Liquid to Adjustment Tank	0.62 hrs	53SS		
55	Rinse Cartridge Filter	0 hrs	54		
56	Changeout Cartridge Filter	0 hrs	55		
57	Send Used Cartridge Filter to Final Conditioning	0 hrs	56		
58					
59	Adjust Filtered Liquid (Batch 2)	49.87 hrs		Adjustment Tank 2	
60	Receive and Store Filtered Liquid	0.62 hrs	54SS		
61	Sample and Wait For Results	48 hrs	60		
62	Add Adjustment Reagents (< 1 liter/batch)	0 hrs	61		
63	Homogenize Adjusted Liquid	0.25 hrs	62		
64	Transfer Adjusted Liquid to Neutralization Tank	1 hr	63		
65					
66	Neutralize Adjusted Liquid (Batch 2)	3.33 hrs		Neutralization Tank	
67	Receive and Store Adjusted Liquid	1.08 hrs	64SS		
68	Add Neutralization Reagents (~16 liters/batch)	0.25 hrs	67		
69	Homogenize and Cool Neutralized Slurry	0.5 hrs	68		
70	Sample Slurry to Confirm TWRS Acceptability	0 hrs	69		
71	Transfer Neutralized Slurry to Transport System	1.5 hrs	70		
72					
73	Transport Neutralized Slurry to TWRS (Batch 2)	9.5 hrs		TWRS Transport	
74	Receive and Load Neutralized Slurry	1.5 hrs	71SS		
75	Transport Slurry to Tank Farms	8 hrs	74		
76					
77	Store Excess Liquid (Batch 3)	1.62 hrs		Clarified Liquid Tank	
78	Receive Excess Liquid (5,527 liters)	1 hr	14SS		
79	Transfer Excess Liquid to Cartridge Filter	0.62 hrs	78		
80					
81	Filter Excess Liquid (Batch 3)	0.62 hrs		Cartridge Filter	
82	Process Excess Liquid Through Cartridge Filter	0.62 hrs	79SS		
83	Transfer Filtered Liquid to Adjustment Tank	0.62 hrs	82SS		
84	Rinse Cartridge Filter	0 hrs	83		

Figure E-1 -- Detailed Process Steps for Grouting Treated Solids (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
85	Changeout Cartridge Filter	0 hrs	84		
86	Send Used Cartridge Filter to Final Conditioning	0 hrs	85		
87					
88	Adjust Filtered Liquid (Batch 3)	49.87 hrs		Adjustment Tank 3	
89	Receive and Store Filtered Liquid	0.62 hrs	83SS		
90	Sample and Wait For Results	48 hrs	89		
91	Add Adjustment Reagents (< 1 liter/batch)	0 hrs	90		
92	Homogenize Adjusted Liquid	0.25 hrs	91		
93	Transfer Adjusted Liquid to Neutralization Tank	1 hr	92		
94					
95	Neutralize Adjusted Liquid (Batch 3)	3.33 hrs		Neutralization Tank	
96	Receive and Store Adjusted Liquid	1.08 hrs	93SS		
97	Add Neutralization Reagents (~16 liters/batch)	0.25 hrs	96		
98	Homogenize and Cool Neutralized Slurry	0.5 hrs	97		
99	Sample Slurry to Confirm TWRS Acceptability	0 hrs	98		
100	Transfer Neutralized Slurry to Transport System	1.5 hrs	99		
101					
102	Transport Neutralized Slurry to TWRS (Batch 3)	9.5 hrs		TWRS Transport	
103	Receive and Load Neutralized Slurry	1.5 hrs	100SS		
104	Transport Slurry to Tank Farms	8 hrs	103		
105					
106	Store Excess Liquid (Batch 4)	1.62 hrs		Clarified Liquid Tank	
107	Receive Excess Liquid (5,527 liters)	1 hr	15SS		
108	Transfer Excess Liquid to Cartridge Filter	0.62 hrs	107		
109					
110	Filter Excess Liquid (Batch 4)	0.62 hrs		Cartridge Filter	
111	Process Excess Liquid Through Cartridge Filter	0.62 hrs	108SS		
112	Transfer Filtered Liquid to Adjustment Tank	0.62 hrs	111SS		
113	Rinse Cartridge Filter	0 hrs	112		
114	Changeout Cartridge Filter	0 hrs	113		
115	Send Used Cartridge Filter to Final Conditioning	0 hrs	114		
116					
117	Adjust Filtered Liquid (Batch 4)	49.87 hrs		Adjustment Tank 1	
118	Receive and Store Filtered Liquid	0.62 hrs	112SS		
119	Sample and Wait For Results	48 hrs	118		
120	Add Adjustment Reagents (< 1 liter/batch)	0 hrs	119		
121	Homogenize Adjusted Liquid	0.25 hrs	120		
122	Transfer Adjusted Liquid to Neutralization Tank	1 hr	121		
123					
124	Neutralize Adjusted Liquid (Batch 4)	3.33 hrs		Neutralization Tank	
125	Receive and Store Adjusted Liquid	1.08 hrs	122SS		
126	Add Neutralization Reagents (~16 liters/batch)	0.25 hrs	125		

Figure E-1 -- Detailed Process Steps for Grouting Treated Solids (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
127	Homogenize and Cool Neutralized Slurry	0.5 hrs	126		
128	Sample Slurry to Confirm TWRS Acceptability	0 hrs	127		
129	Transfer Neutralized Slurry to Transport System	1.5 hrs	128		
130					
131	Transport Neutralized Slurry to TWRS (Batch 4)	9.5 hrs		TWRS Transport	
132	Receive and Load Neutralized Slurry	1.5 hrs	129SS		
133	Transport Slurry to Tank Farms	8 hrs	132		
134					
135	Store Excess Liquid (Batch 5)	1.62 hrs		Clarified Liquid Tank	
136	Receive Excess Liquid (5,527 liters)	1 hr	16SS		
137	Transfer Excess Liquid to Cartridge Filter	0.62 hrs	136		
138					
139	Filter Excess Liquid (Batch 5)	0.62 hrs		Cartridge Filter	
140	Process Excess Liquid Through Cartridge Filter	0.62 hrs	137SS		
141	Transfer Filtered Liquid to Adjustment Tank	0.62 hrs	140SS		
142	Rinse Cartridge Filter	0 hrs	141		
143	Changeout Cartridge Filter	0 hrs	142		
144	Send Used Cartridge Filter to Final Conditioning	0 hrs	143		
145					
146	Adjust Filtered Liquid (Batch 5)	49.87 hrs		Adjustment Tank 2	
147	Receive and Store Filtered Liquid	0.62 hrs	141SS		
148	Sample and Wait For Results	48 hrs	147		
149	Add Adjustment Reagents (< 1 liter/batch)	0 hrs	148		
150	Homogenize Adjusted Liquid	0.25 hrs	149		
151	Transfer Adjusted Liquid to Neutralization Tank	1 hr	150		
152					
153	Neutralize Adjusted Liquid (Batch 5)	3.33 hrs		Neutralization Tank	
154	Receive and Store Adjusted Liquid	1.08 hrs	151SS		
155	Add Neutralization Reagents (~16 liters/batch)	0.25 hrs	154		
156	Homogenize and Cool Neutralized Slurry	0.5 hrs	155		
157	Sample Slurry to Confirm TWRS Acceptability	0 hrs	156		
158	Transfer Neutralized Slurry to Transport System	1.5 hrs	157		
159					
160	Transport Neutralized Slurry to TWRS (Batch 5)	9.5 hrs		TWRS Transport	
161	Receive and Load Neutralized Slurry	1.5 hrs	158SS		
162	Transport Slurry to Tank Farms	8 hrs	161		
163					
164	Store Excess Liquid (Batch 6)	1.62 hrs		Clarified Liquid Tank	
165	Receive Excess Liquid (5,527 liters)	1 hr	17SS		
166	Transfer Excess Liquid to Cartridge Filter	0.62 hrs	165		
167					
168	Filter Excess Liquid (Batch 6)	0.62 hrs		Cartridge Filter	

Figure E-1 -- Detailed Process Steps for Grouting Treated Solids (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
169	Process Excess Liquid Through Cartridge Filter	0.62 hrs	166SS		
170	Transfer Filtered Liquid to Adjustment Tank	0.62 hrs	169SS		
171	Rinse Cartridge Filter	0 hrs	170		
172	Changeout Cartridge Filter	0 hrs	171		
173	Send Used Cartridge Filter to Final Conditioning	0 hrs	172		
174					
175	Adjust Filtered Liquid (Batch 6)	49.87 hrs		Adjustment Tank 3	
176	Receive and Store Filtered Liquid	0.62 hrs	170SS		
177	Sample and Wait For Results	48 hrs	176		
178	Add Adjustment Reagents (< 1 liter/batch)	0 hrs	177		
179	Homogenize Adjusted Liquid	0.25 hrs	178		
180	Transfer Adjusted Liquid to Neutralization Tank	1 hr	179		
181					
182	Neutralize Adjusted Liquid (Batch 6)	3.33 hrs		Neutralization Tank	
183	Receive and Store Adjusted Liquid	1.08 hrs	180SS		
184	Add Neutralization Reagents (~16 liters/batch)	0.25 hrs	183		
185	Homogenize and Cool Neutralized Slurry	0.5 hrs	184		
186	Sample Slurry to Confirm TWRS Acceptability	0 hrs	185		
187	Transfer Neutralized Slurry to Transport System	1.5 hrs	186		
188					
189	Transport Neutralized Slurry to TWRS (Batch 6)	9.5 hrs		TWRS Transport	
190	Receive and Load Neutralized Slurry	1.5 hrs	187SS		
191	Transport Slurry to Tank Farms	8 hrs	190		
192					
193					
194					
195	Grout Slurry	0 hrs			12:00
196	Assume this will done in 6 full batches, plus 1 partial	0 hrs			12:00 A
197	Assume 1 Grout Liner position available in Pit	0 hrs			12:00 A
198					
199	Prepare Slurry	58 hrs		Solids Reception Tank	
200	Homogenize Remaining Slurry	8 hrs	17FS+1 hr		
201	Sample Slurry and Wait For Results	2 days	200		
202	Restart Homogenization System	2 hrs	201		
203					
204	Transfer Slurry to Grout Liner	360.67 hrs		Solids Reception Tank	
205	Transfer 2,846 liters of slurry to liner 1	1 hr	202		
206	Transfer 2,846 liters of slurry to liner 2	1 hr	225		
207	Transfer 2,846 liters of slurry to liner 3	1 hr	236		
208	Transfer 2,846 liters of slurry to liner 4	1 hr	247		
209	Transfer 2,846 liters of slurry to liner 5	1 hr	258		
210	Transfer 2,846 liters of slurry to liner 6	1 hr	269		

Figure E-1 - Detailed Process Steps for Grouting Treated Solids (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
211	Transfer 1,889 liters of slurry to liner 7	0.67 hrs	280		
212					
213	Fill Liner 1	56 hrs		Liner Pit	
214	Place Empty Liner in Pit	2 hrs	201		
215	Receive slurry	1 hr	205SS		
216	Add Grout Formers	1 hr	215		
217	Cure Grout Product in Liner Pit	2 days	216		
218	Cap and Seal Grout Liner	4 hrs	217		
219					
220	Transport Grout Liner 1	12 hrs		Liner Transport	
221	Load Grout Liner on Transport	4 hrs	218		
222	Transfer Filled Grout Liner to ERDF	8 hrs	221		
223					
224	Fill Liner 2	56 hrs		Liner Pit	
225	Place Empty Liner in Pit	2 hrs	221		
226	Receive slurry	1 hr	206SS		
227	Add Grout Formers	1 hr	226		
228	Cure Grout Product in Liner	2 days	227		
229	Cap and Seal Grout Liner	4 hrs	228		
230					
231	Transport Grout Liner 2	12 hrs		Liner Transport	
232	Load Grout Liner on Transport	4 hrs	229		
233	Transfer Filled Grout Liner to ERDF	8 hrs	232		
234					
235	Fill Liner 3	56 hrs		Liner Pit	
236	Place Empty Liner in Pit	2 hrs	232		
237	Receive slurry	1 hr	207SS		
238	Add Grout Formers	1 hr	237		
239	Cure Grout Product in Liner	2 days	238		
240	Cap and Seal Grout Liner	4 hrs	239		
241					
242	Transport Grout Liner 3	12 hrs		Liner Transport	
243	Load Grout Liner on Transport	4 hrs	240		
244	Transfer Filled Grout Liner to ERDF	8 hrs	243		
245					
246	Fill Liner 4	56 hrs		Liner Pit	
247	Place Empty Liner in Pit	2 hrs	243		
248	Receive slurry	1 hr	208SS		
249	Add Grout Formers	1 hr	248		
250	Cure Grout Product in Liner	2 days	249		
251	Cap and Seal Grout Liner	4 hrs	250		
252					

Figure E-1 -- Detailed Process Steps for Grouting Treated Solids (cont.)

ID	Task Name	Duration	Predecessors	Resource Names	1
253	Transport Grout Liner 4	12 hrs		Liner Transport	
254	Load Grout Liner on Transport	4 hrs	251		
255	Transfer Filled Grout Liner to ERDF	8 hrs	254		
256					
257	Fill Liner 5	56 hrs		Liner Pit	
258	Place Empty Liner in Pit	2 hrs	254		
259	Receive slurry	1 hr	209SS		
260	Add Grout Formers	1 hr	259		
261	Cure Grout Product in Liner	2 days	260		
262	Cap and Seal Grout Liner	4 hrs	261		
263					
264	Transport Grout Liner 5	12 hrs		Liner Transport	
265	Load Grout Liner on Transport	4 hrs	262		
266	Transfer Filled Grout Liner to ERDF	8 hrs	265		
267					
268	Fill Liner 6	56 hrs		Liner Pit	
269	Place Empty Liner in Pit	2 hrs	265		
270	Receive slurry	1 hr	210SS		
271	Add Grout Formers	1 hr	270		
272	Cure Grout Product in Liner	2 days	271		
273	Cap and Seal Grout Liner	4 hrs	272		
274					
275	Transport Grout Liner 6	12 hrs		Liner Transport	
276	Load Grout Liner on Transport	4 hrs	273		
277	Transfer Filled Grout Liner to ERDF	8 hrs	276		
278					
279	Fill Liner 7	55.67 hrs		Liner Pit	
280	Place Empty Liner in Pit	2 hrs	276		
281	Receive slurry	0.67 hrs	211SS		
282	Add Grout Formers	1 hr	281		
283	Cure Grout Product in Liner	2 days	282		
284	Cap and Seal Grout Liner	4 hrs	283		
285					
286	Transport Grout Liner 7	12 hrs		Liner Transport	
287	Load Grout Liner on Transport	4 hrs	284		
288	Transfer Filled Grout Liner to ERDF	8 hrs	287		
289					
290					
291	Grout Used Cartridge Filters	0 hrs			12:00 A
292	Receive Used Cartridge Filters	0 hrs			12:00 A
293	Load Cartridge Filters in Drum	0 hrs			12:00 A
294	Store Filters in Drums	0 hrs			12:00 A