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Fate of Copper and Silver from RFID Labels During Recycling of OCC and Potential Environmental and Product Implications

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by

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EXECUTIVE SUMMARY

A research study was conducted to examine the environmental and product quality implications of recycling old corrugated container (OCC) containing radio frequency identification (RFID) tags. A preliminary study determined that the currently available plastic laminated copper foil antennae maintain their integrity during hydrapulping and are removed during initial screening and cleaning and were not further considered. Silver from conductive silver ink used in RFID antennae was tracked as RFID-bearing corrugated container clippings were processed through a pilot-scale recycling plant. Silver concentrations were measured in four output vectors: screening and cleaning rejects, whitewater settled solids, whitewater effluent, and product in runs conducted with and without RFIDs. Relative percentages of the mass of incoming silver found in each output vector, after subtracting background silver, are shown in Table ES-1.

Table ES-1 Relative Silver Percentage by Output Vector

DISTRIBUTION OF INCOMING SILVER ACROSS OUTPUT VECTORS	
Screening/Cleaning Rejects[1]	4.1 % ± 0.6 %[2]
Whitewater settled solids	8.9 % ± 1.4 %
Whitewater effluent	3.4 % ± 0.7%
Product	84 % ± 1.9 %

[1]Value of 4.5% reject rate was assumed as discussed in Section 4.
[2] 95% confidence interval around the mean

Data from the pilot plant runs were used with lower 25th percentile values for residuals and wastewater generation rates to update NCASI's spreadsheet model to estimate concentrations that might occur in wastewater, solids, and product from a hypothetical mill recycling RFID-tagged OCC. These concentrations were compared to appropriate water quality criteria, disposal limits, or product limits. The results indicate that with the input conditions used to run the spreadsheet model, no applicable regulatory limits would be exceeded.

1.0 INTRODUCTION

As Radio Frequency Identification (RFID) tags come into widespread use, it is expected that increasing numbers of these devices will enter recycling mills as part of the old corrugated container (OCC) furnish. Because some of these devices use copper foil or conductive silver ink in antennae, the fate of this silver in OCC recycling operations may be of concern. Potential concerns may arise if silver is present in wastewater, solid residuals, or product at concentrations that approach or exceed regulatory limits. A preliminary desktop investigation using a spreadsheet mass balance model and a wide range of assumptions about partitioning of the silver to the output vectors indicated sufficient potential for regulatory concerns, particularly in wastewater, to warrant more detailed studies[1].

Using a pilot plant-scale recycling process, the study reported here examined the silver concentration in four output vectors that included screening and cleaning rejects, whitewater settled solids (residuals), whitewater effluent, and product. The primary objective was to reduce the considerable uncertainty regarding the partitioning of silver from RFIDs to these output vectors.

2.0 BACKGROUND

Current RFID construction includes a small integrated circuit and an antenna that is either in foil form (copper) or printed with conductive silver ink. The RFID antennae are a potential source of metals that may be mobilized during the recycling process and the effect of recycling OCC containing RFID tags on environmental and product concentrations of silver and copper needs to be assessed.

Because RFIDs utilizing copper foil antennae are typically enclosed in a plastic laminate that is adhesively attached to containers, it is likely that this laminate will maintain its integrity in the hydrapulper and be captured in reject streams. Furthermore, even if delamination occurs, the copper is in a foil form, and is likely to act significantly differently, both chemically and physically, from an equivalent mass of metal in the particulate form (particle sizes 2-3 μm) associated with conductive inks. NCASI conducted a preliminary study which determined that currently available Alien Printronix® copper foil antenna RFIDs adhesively attached to OCC maintain their integrity during pulping in a medium consistency hydrapulper. The RFIDs were readily removed (98% removal) from the pulp at the hydrapulper extraction plate. Therefore, the remainder of this study considered silver as the only RFID associated metal. The preliminary study is discussed in Appendix A.

This investigation was designed to improve upon the desktop review by measuring the partitioning of RFID silver in a pilot plant set up to simulate, as closely as possible, OCC processing in a full-scale mill operation. Each unit operation in the pilot plant was conducted in batch mode, and therefore, was operated for a predetermined amount of time to reach steady state conditions before samples were collected. Data used to calculate the partitioning of silver

[1] NCASI June 4, 2004 memo from Van Maltby to Reid Miner, Jay Unwin.

were collected only after the batch operations were determined to have reached steady state conditions reflective of conditions that would exist in a mill operating continuously.

2.1 Pilot Plant

This research was conducted at pilot-scale recycling and papermaking facilities at Western Michigan University. The pilot plant was configured to simulate a "model" mill, the details of which were chosen in consultation with the Fibre Box Association (FBA). The pilot plant unit operations included

- hydrapulper;
- screening and cleaning stages;
- paper machine;
- primary wastewater treatment (settling column).

Figure 2.1 indicates the major components of the pilot plant that were utilized for this research and identifies primary sample collection points. Unit operations were operated at conditions (pressure, time, etc.) considered by pilot plant personnel to be typical of industry operations. Time to steady state for each unit operation was estimated in advance of the study and verified during each run. Specifications and photographs of the pilot plant can be found at http://www.wmich.edu/recyclingplant/fiber.html. Primary wastewater treatment was simulated by settling a portion of the paper machine whitewater collected in a settling column.

2.2 Furnish

With the assistance of Fibre Box Association (FBA), NCASI obtained representative samples of recycled corrugated container board clippings as a surrogate for OCC. Because OCC is composed of material from a variety of sources, it could be difficult to establish a representative background silver level, especially if more than one bale of OCC were used. The three bales (1000 lb/bale) of recycled corrugated containerboard used in this study were obtained from one source to minimize variability due to the material itself.

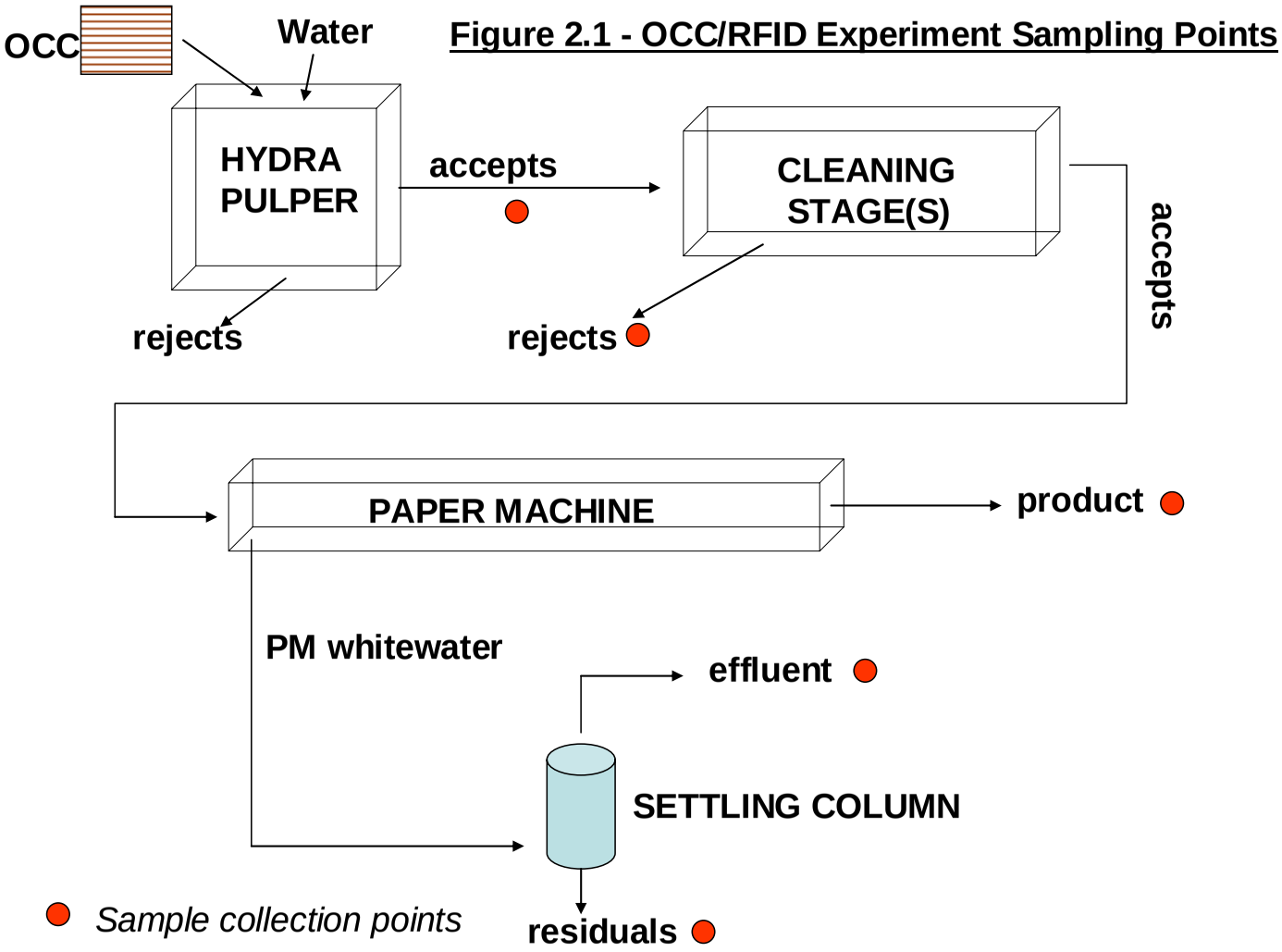


Figure 2.1 - OCC/RFID Experiment Sampling Points

2.3 RFID Antenna Design

Several printed ink antenna designs are under consideration by manufacturers. Conductive ink formulations include water-based and solvent-based flexographic inks, and lithographic ink paste. Printing media include coated label stock and polyester film, and the printed antennae may be "sandwiched" between two laminated layers. At this time, no combination of the variables above has emerged as a dominant design. This study used a conservative design consisting of a water-based flexographic antenna printed on coated label stock without a protective overlying laminate layer. It is considered conservative because during hydrapulping, the paper base is more likely to be pulped, more ink is likely to be mobilized without the protective laminate layer, and the water used in pulping may be more likely to resuspend the silver particles in a water-based ink.

Precisia, a division of Flint Inks Inc., provided the RFIDs for the research study. NCASI consulted with Precisia to determine the size and geometry of a "typical" dipole antenna constructed from silver conductive ink. The antenna design selected was the "Alien I2" series with an antenna surface area of 7.327 cm^2 (Figure 2.1). Precisia printed 2000 RFID tags using flexographic conductive ink. The antennae were printed in three flexographic passes that resulted in a dry ink film thickness of 7.5 µm. Antennae were printed onto coated label stock (4 x 8 inch) with pressure sensitive adhesive (PSA) and release paper applied to the back side. The mass of silver on each tag averaged 15.7 mg.

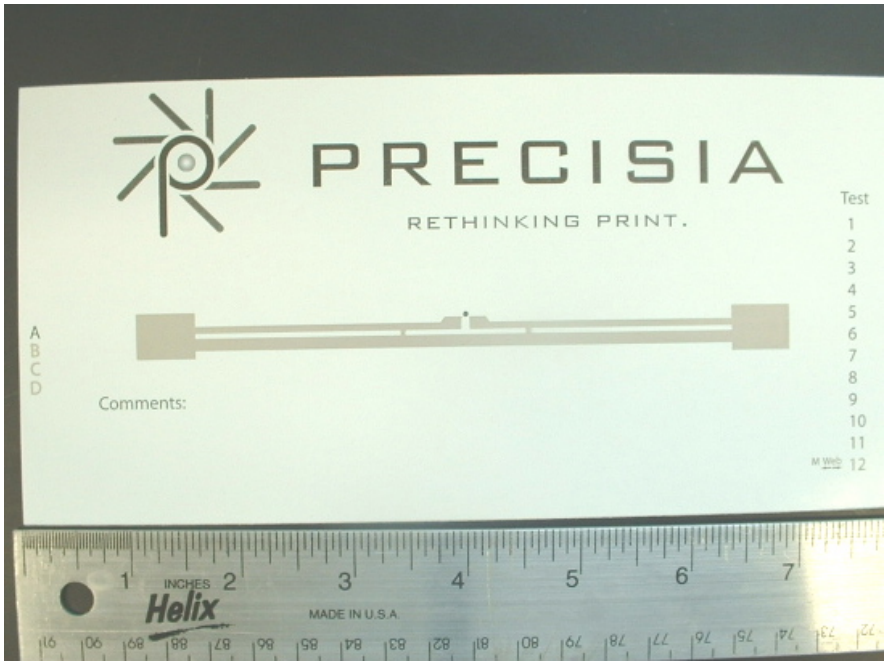


Figure 2.1 Precisia Alien I2 RFID Tag

3.0 RESEARCH STUDY DESIGN AND PROCEDURES

This study consisted of two pilot plant runs: a control or baseline run (no RFIDs) to determine background silver levels, and a run with RFIDs. A brief description of the experimental design features with a description of unit operations follows. A comprehensive description of unit operation quantification and sampling procedures is presented in Appendix B.

3.1 Run Description

Each run was initiated with 600 (dry weight) pounds of clippings processed in two 300-lb discrete batches in the hydrapulper. The resulting pulp was mixed and stored in a 5000-gallon stock chest. The pulp was processed through the screening and cleaning unit operations and sent to the paper machine for board production. Paper machine whitewater was collected and a portion was settled in a settling column to simulate primary treatment. For each run, sufficient data and samples were collected under steady state conditions to conduct three mass balances around the pilot plant: a water balance, a fiber balance, and a silver balance. It is important to note that "steady state" refers to equipment operating conditions (e.g., flow rates, pressures). It was assumed that silver partitioning is more likely to be at steady state once pilot plant equipment and fiber processing had reached steady state than would be the case at non-steady state operation.

3.2 RFID Label Attachment

RFID labels were affixed to the recycled containerboard at a rate of approximately one label per pound of board[2]. Because the board consisted of clippings that were often smaller than the label and irregular in shape, several pieces of clippings were typically attached to each label. Figure 3.1 illustrates the clippings with RFID labels attached.

3.3 Hydrapulper Batches

Only two of the three 1000-lb bales provided to NCASI were required to conduct two runs. In order to minimize any physical differences in clippings between the two bales, each bale was alternately sampled until a 300-lb dry batch (one hydrapulper batch) was obtained. Clippings were not sorted or screened. However, any foreign material found in the clippings (baling wire, plastic, Styrofoam, other material, etc.) was removed by hand. The amount of such material was negligible.

[2] As suggested by Fibre Box Association, recorded in June 2, 2004 email from Reid Miner to Van Maltby. Actual addition rate was 1.07 RFID/dry lb clippings.

Figure 3.1 Sample of Clippings with RFID Labels Attached

The baseline hydrapulper run was done at 125ºC for approximately 60 minutes. The RFID hydrapulper run was done at 140ºC for approximately 40 minutes. The higher temperature was used to help overcome the wet strength of the clippings. Sufficient water was added to achieve a post-pulping consistency of 1.5% solids.

At the end of each hydrapulping batch, a small amount of reject material (approximately 1 lb) was collected at the extractor plate. This material consisted of small pieces of wood (pallet splinters), foam, plastic envelope windows, adhesive stick–on labels, and some clumps of wet strength OCC. These materials were not analyzed for silver.

3.4 Screening and Cleaning Unit Operations

Pulp was processed through five discrete screening and cleaning unit operations as batch processes:

- primary screen – coarse;
- primary screen – fine;
- forward centricleaners;
- reverse centricleaners (two separate passes).

Between each of the screening and cleaning unit operations, volume measurements were made of the steady state accepts and rejects, along with the same measurements made for non-steady state accepts and rejects. Pulp was stored in stock chests between the batch processes and steady state rejects were stored in either a stock chest or in stainless steel tanks. Measurements were also made of pulp losses associated with each unit operation due to tank/chest residuals, sumps, and plumbing, etc. Figure 3.2 shows the general layout and sequence of the screening and cleaning unit operations.

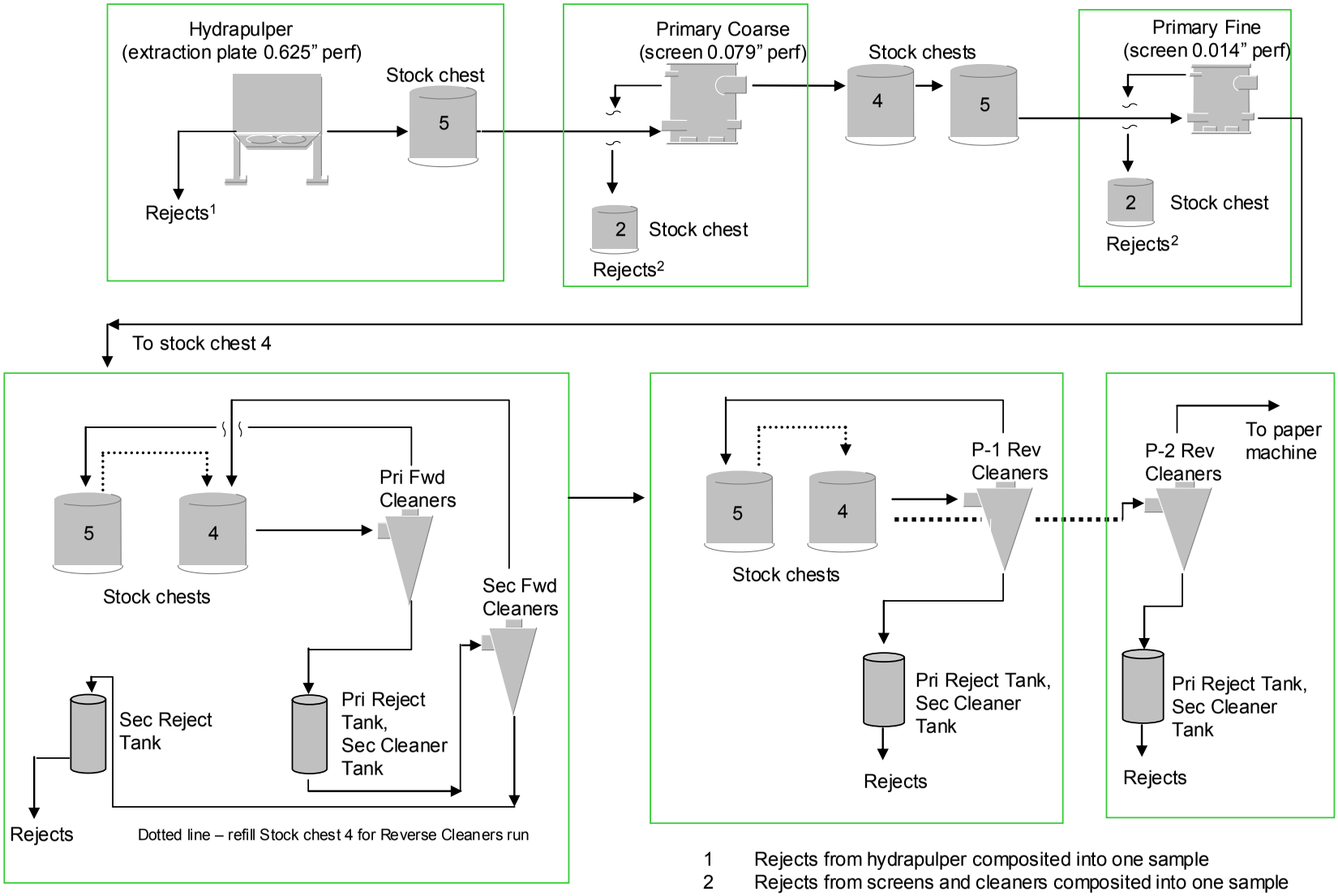
The five screening and cleaning unit operations described above resulted in five separately collected and quantified reject volumes. A subset of approximately 10-15 gallons of rejects was collected from each of the five unit operations and stored in 30-gal barrels.

The silver concentration associated with these rejects was represented in a composite made from the reject materials in all five barrels. The rejects from the individual screening and cleaning batch operations were combined in proportions estimated to have occurred had the operations been run together in a continuously operating mill. These rejects were combined into a single barrel from which samples were collected.

3.5 Paper Machine

After the pulp screening and cleaning unit operations were completed, the remaining pulp was sent to the paper machine for board production with a basis weight of 121 lb/3000 ft^2. Prior to steady state conditions, board was collected on an end roll but not quantified. At steady state conditions the board was tagged and steady state production continued for approximately 20 minutes.

Figure 3.2 WMU Pilot Plant Screening/Cleaning Stages, (unit operations)



1 Rejects from hydrapulper composited into one sample
2 Rejects from screens and cleaners composited into one sample

3.6 Paper Machine Whitewater

During steady state papermaking, all paper machine whitewater was collected and quantified in a completely mixed stock chest. At the end of a run, a portion of the completely mixed whitewater was pumped to an 8-ft high, 6-in diameter settling column and allowed to settle for three hours in order to approximate conditions in a primary clarifier. Samples of the whitewater settled solids were collected from the column drain and samples of clarified whitewater were collected from one of the uppermost sampling ports.

3.7 Accept and Reject Volume Measurements

Volumes of accepts or rejects were either directly measured using liquid levels and tank geometry or indirectly measured by refilling stock chests to a reference point using a calibrated water flowmeter.

3.8 Sample Collection

To determine the partitioning of silver across the four output vectors, samples were collected for silver analysis from five matrices (pulp and the four output vectors including screening and cleaning rejects, clarified whitewater, whitewater solids, and product). Twenty-eight (28) replicate samples from each of the five matrices were collected during each pilot plant run to (1) provide for the detection of a 20% difference in silver concentration between RFID and background runs in all vectors with 95% confidence assuming a coefficient of variation in the silver data of 20%, and (2) estimate the proportion of silver in each vector to within 20% of the observed mean proportion (USEPA 2001).

Because each unit operation was a batch process, samples were collected only after equipment was determined to be operating at steady state conditions. While the sampling details changed slightly between different unit operations due to uniqueness in equipment and associated plumbing, the sample collection strategy was similar for all unit operations and is described in Appendix B. Individual archival samples of outputs were collected from various unit operations and stored in the event that additional unanticipated information is needed.

Other ancillary determinations made during the runs included hydrapulper pulp temperature, oxidation reduction potential (ORP), pH, and other general water quality chemical parameters.

3.9 Silver Analytical Methods

Silver analysis was conducted by KAR Laboratories in Kalamazoo, Michigan. Samples were analyzed using EPA Method 200.8 (aqueous) and EPA Method 6020 (solids). Prior to analysis, samples were digested using a modified version of EPA Method 3050B. The digestion procedures used by KAR Laboratories were modified to make them more aggressive and improve the recovery of silver. Matrix spikes consisting of pieces of the Precisia antennae of a known surface area (small paper punch used) were added to the baseline samples of all five matrices analyzed. A copy of the modified digestion procedure for aqueous and solid samples and the raw analytical data are included in Appendix C.

4.0 RESULTS

4.1 Data Quality Assessment

All quality assurance/quality control procedures specified in the analytical methods were followed. The relative percent difference of duplicate silver analyses was less than 20% for RFID samples and less than 38% for baseline samples. Silver recovery in matrix spike samples was between 92% and 174% for all matrices analyzed (at least 2 per matrix) with an average of 121%. Method detection limits of 1ppb were achieved for aqueous matrices and 0.5 ppm for solid matrices. Silver concentration data are considered to be of acceptable quality, and are provided in Appendix C.

4.2 Calculation of RFID Silver Distribution

Silver concentrations in the various media from the RFID run were adjusted by subtracting background concentrations observed in the baseline run. These background-adjusted concentrations were then used in subsequent calculations of the distribution of silver to the output vectors. Because a significant number of the samples from the baseline run had silver concentrations at or below the detection limit, we examined the effect of treating non-detect (ND) values in different manners. The ND treatments included (1) NDs equal to the detection limit, (2) NDs equal to one-half the detection limit, and (3) NDs equal to zero. We selected ND equal to zero because it maximized the relative difference in silver concentrations between the RFID run and the baseline run. However, we also determined that the effect of different detection limit assumptions on the estimated distribution of silver from RFID tags was negligible.

In a continuous process typical of a full-scale recycling operation, the distribution of silver in process output vectors can be directly assessed using measurements of silver concentration and vector flows/production rate from all vectors during steady state operation. Because the pilot plant processes could only be operated in batch mode, with the potential for sewer losses of solids, water, and silver between processes, calculation of silver distribution that combined batch screening/cleaning and papermaking processes was somewhat more complex.

In general, the procedure involved estimating the proportional distribution within each batch process using measured silver concentrations and process material volumes (for paper machine whitewater solids and effluent and cleaning stage rejects) or mass (for product). Because cleaning stage accepts were not sampled directly, the silver mass was estimated as the difference between the silver mass in the hydrapulper stock chest and the silver mass in the cleaning stage rejects (accounting for non-steady state sewer losses). The masses of silver in each of the three paper machine vectors were summed to yield an estimate of the total silver processed across the paper machine. We assumed that there were no significant losses of silver to other vectors. The estimated silver masses and proportions in the four process vectors are shown in Table 4.1. A more detailed description of the distribution of silver calculations is presented in Appendix D.

Within the scope of this study, it was not feasible to incorporate additional fiber recovery operations (flotation tanks, stock savers, save-alls) typically associated with full-scale screening and cleaning. The majority of fiber recovered in those operations may be returned

to the process where it ultimately finds its way to the paper machine. A large and unrepresentative amount of usable fiber was rejected in the pilot plant screening and cleaning stages. Because we were unable to simulate recovery of this fiber, we have assumed approximately 95% of all of the fiber associated with the screening/cleaning rejects would have been used as furnish for the paper machine with the associated silver being distributed among the remaining vectors in the same proportions just as the silver was in the study. The "adjusted" percentages in the last column of Table 4.1 reflect this assumption.

Table 4.1 Distribution of Incoming Silver across Process Vectors

Output Vector	Percent (observed)[1]	Percent (adjusted)[1,2]
Screening/cleaning rejects	63 % ± 10 %	4.1 % ± 0.6 %
Whitewater settled solids	3.4 % ± 1.1 %	8.9 % ± 1.4 %
Whitewater effluent	1.3 % ± 0.4 %	3.4 % ± 0.7 %
Product	32 % ± 8.8 %	84 % ± 1.9 %

[1] 95% confidence interval around the mean is discussed in Section 5.3.
[2] Adjusted value is based on a 4.5% screening/cleaning reject rate as suggested by FBA representatives based, on Tappi (2000).

5.0 UNCERTAINTY ASSOCIATED WITH ESTIMATES OF SILVER DISTRIBUTIONS

5.1 Silver Concentration Measurements

During the research planning phase, the number of samples collected from each matrix (e.g., product, whitewater effluent, etc.) during each run was estimated based on a goal of detecting a 20% difference between RFID and baseline average silver concentrations with 95% confidence, assuming that the data were normally distributed and coefficients of variation for all matrices were 20%. Actual coefficients of variation for the RFID runs ranged from 6.5% in the whitewater solids samples to 34% in the paper machine product samples. The coefficients of variation for the five baseline matrices were many times higher, with the exception of the paper machine baseline product samples in which all silver measurements were below detection limits. The very large coefficients of variation for the baseline samples were the result of many non-detects and a few measurements above the detection limits among the within-matrix replicates.

Although the observed coefficients of variation were higher than 20% in most of the sampled matrices, the data clearly establish the presence of greater than a 20% difference in silver concentrations between baseline and RFID runs for all five matrices regardless of the treatment of non-detects in baseline samples. The average silver concentration in the five RFID matrices exceeded the average concentration in the baseline samples by approximately six times in the case of whitewater effluent, and by more than an order of magnitude in all

other matrices. This results in a level of confidence in the presence of a 20% difference between RFID and baseline averages that is well above 95%.

5.2 Volume and Fiber Mass Measurements

Estimates of silver proportions in each output vector during the RFID run were generated by combining average silver concentrations in each vector with the corresponding volume (whitewater effluent and solids) or fiber mass (paper machine product only) estimate. The proportion of solids in screening/cleaning rejects was assumed to be 4.5% due to the recycling of this material back to the paper machine, as previously discussed.

The estimated mass of paper product produced during steady state operation, accounting for uncertainty in the scale used to weigh the material and in the moisture content of the finished product is believed to be accurate within +/-10%. Estimates of the volumes of steady state whitewater effluent and settled solids are also believed to be accurate within +/-10%.

5.3 Vector Silver Distribution and Error Bound Calculation

Replication in measured silver concentrations and vector mass/volumes from the RFID and baseline runs provided estimated mean values and associated error bounds for each parameter. This information was used to estimate the uncertainty of the silver distribution estimates among the four process vectors.

The baseline mean silver concentrations were first subtracted from the means from the RFID run. Because the baseline mean concentrations were small relative to the means from the RFID run, the standard deviations and number of replicate measurements from the RFID run were used with the baseline-adjusted means to calculate standard errors for each adjusted mean.

The adjusted means and standard errors for the parameters measured in the experiment, were used to generate 1000 sets of random numbers for each measured parameter, as shown in Table 5.1.

Table 5.1 Measured Silver Concentrations and Output Vector Volumes or Masses

	WW Effluent		**WW Solids**		**Product**		**S/C Rejects***	
	Mg/L silver	Gallons	Mg/L silver	Gallons	Mg/Kg silver	Pounds	Mg/L silver	Gallons
Mean	0.0070	395	0.064	115	12.6	46	0.57	131
Std Err	0.0004	20	0.001	6	0.8	2.3	0.03	6.7

*equivalent volume for 4.5% reject solids at 1.82% consistency based on pilot study measurements

Each set of random numbers generated represents combinations of mean silver concentrations and vector volume/mass that would be used to calculate silver mass distribution from a hypothetical RFID experiment as described in Section 4.2. The probability of observing each value in the hypothetical set (i.e., using a random number generator) is established by the observed mean and standard error from the actual experiment, assuming normally distributed data. Generating a relatively large number (1000 in this case) of sets of hypothetical silver concentration and vector volume/mass values allows the probable range of silver distribution values to be estimated using the approach described in Section 4.2. Summary statistics from the 1000 hypothetical experiments using means and standard errors from the pilot plant study are shown in Table 5.2 below.

Table 5.2 Summary Statistics from 1000 RFID Experiment Simulations

	WW Effluent		**WW Solids**		**Product**		**S/C Rejects**	
	mg/L	gallons	mg/L	gallons	mg/L	dry wt (kg)	mg/L	gallons
Mean	0.0070	396	0.064	115	12.6	46	0.57	131
Stdev	0.0004	21	0.001	6	0.8	2	0.03	7
CV	5.9	5.3	1.2	5.1	6.1	5	6.1	5.1
Count	1000	1000	1000	1000	1000	1000	1000	1000
Min	0.0054	329	0.062	92	10.3	39	0.46	108
Max	0.0083	459	0.067	137	14.9	55	0.69	154

The 95% confidence interval around the mean silver mass proportion was determined for each vector using the 2.5^{th} and 97.5^{th} percentile values obtained from the distribution of mean proportions in the 1000 hypothetical experiments. These values are shown in Table 4.1. Due in large part to the number of replicate silver concentrations measurements (28 in each vector), silver distribution can be estimated using the above approach to within 21% of the observed mean for all vectors.

5.4 Mass Balance

As an additional approximate check on the quality of measurements made during the RFID run, water, solids, and silver material balances were evaluated. In each case, measurements of the volume, solids content, and/or silver concentration in the contents of Stock Chest 5 after hydrapulping (see Figure 3.2) were compared with the sum of corresponding values from the four output vectors, i.e., screening/cleaning rejects, and paper machine product, whitewater settled solids, and whitewater effluent. Stock Chest 5 after hydrapulping was selected as the starting point for material balance calculations because, following the study design, this location was sampled with a similar level of effort as the four output vector locations. Material balance results are shown in Table 5.3.

Table 5.3 Material Balance Results

	Volume (gallons)	**Solids (kg)**	**Silver (mg)**
Stock Chest 5 after hydrapulping	**4264**	**205**	**7101**
Screening/Cleaning Accepts (ready for paper making)	1741	76	Not measured
Output Vectors and Sewer Losses			
Screening/Cleaning Rejects	1936	133	4406
Product[1]	1	72	900
Whitewater Settled Solids[1]	397	1.7	97
Whitewater Effluent[1]	1362	1	38
Sewer Losses	319	18[2]	630[2]
Output Vector/Sewer Loss Total	**4015**	**226**	**6071**
Material Balance			
Output/Sewer Loss as % of Stock Chest 5 after hydrapulping	**94%**	**110%**	**85%**

[1] The observed steady state volume of water and mass of solids and silver in paper machine output vectors was divided by 0.29 to estimate the expected volumes and masses had the entire volume of screening/ cleaning accepts been processed at steady state (refer to text in Water Balance section below). Observed steady state water volumes were 0.3, 115, and 395 gallons for product, whitewater settled solids, and whitewater effluent, respectively. Observed steady state solids masses were 21, 0.5, and 0.3 kg for product, whitewater settled solids, and whitewater effluent, respectively. Observed steady state silver masses were 261, 28, and 11 mg, for product, whitewater settled solids, and whitewater effluent, respectively.

[2] based on an assumed consistency of 1.5%

5.4.1 *Water Balance*

A total of 4264 gallons of pulped fiber slurry was measured in Stock Chest 5 after hydrapulping. As described elsewhere in this report, this slurry was subsequently processed through several screening/cleaning stages, producing screening/cleaning accepts and rejects. In addition, 319 gallons were lost to the sewer between batch screening/cleaning processes, typically as material that could not be emptied from tanks, pumps, and connecting pipes. The

volume of screening/cleaning accepts measured in Stock Chest 5, used as the feed tank to the paper machine (see Figure 3.2), was 1741 gallons.

A total of 510 gallons of paper machine whitewater (prior to settling) was collected during 20 minutes of steady state paper machine operation, indicating that roughly 29% of the 1741 gallons of screening/cleaning accepts was used during this period. In order to incorporate them into the overall process material balances, the observed steady state quantities in paper machine output vectors (product, whitewater settled solids, and whitewater effluent) were therefore divided by 29% to estimate the quantities that would have been produced had all the screening/cleaning accepts been processed into product. The resulting estimated water volumes in product, whitewater settled solids, and whitewater effluent were 1 gallon, 397 gallons, and 1362 gallons, respectively.

The total volume of all output vectors and all sewer losses (4015 gallons) represents 94% of the volume measured in Stock Chest 5 after hydrapulping (4264 gallons), showing good agreement among measured values.

5.4.2 *Solids Balance*

A total of 205 kg of dry solids were found in Stock Chest 5 after hydrapulping. Approximately 133 kg dry solids were measured in the screening/cleaning rejects. In addition, some solids were sewered. The mass of solids sewered during cleaning and screening operations was not measured directly; however, based on an estimated sewered volume of 319 gallons and an assumed overall solids consistency of 1.5%, the mass of solids sewered is estimated to be 18 kg.

The observed masses of dry solids in the paper machine output vectors collected during steady state operation were divided by 29% to estimate the masses had all the accepts been processed (see Water Balance discussion). The resulting masses of solids in product, whitewater settled solids, and whitewater effluent were 72 kg, 1.7 kg, and 1 kg, respectively.

The sum of the masses in all output vectors and estimated sewer losses is 226 kg or 110% of the mass observed in Stock Chest 5 after hydrapulping. Thus, solids data collected during the RFID run indicate a sufficient material balance with respect to dry solids.

5.4.3 *Silver Balance*

A total mass of 7101 mg of silver was found in Stock Chest 5 after hydrapulping. Approximately 4406 mg of silver was measured in the screening/cleaning rejects. The mass of silver lost to sewers during screening/cleaning was about 630 mg.

The observed silver masses in the paper machine output vectors collected during steady state operation were divided by 29% to estimate the masses had all the accepts been processed (see Water Balance discussion). The resulting masses of silver in product, whitewater settled solids, and whitewater effluent were 900 mg, 97 mg, and 38 mg, respectively.

The sum of the masses in all output vectors and estimated sewer losses is 6071 mg or 85% of the starting mass in Stock Chest 5. This indicates reasonably good agreement and a sufficient accounting of RFID silver to meet the RFID study objectives.

6.0 UPDATE TO NCASI SPREADSHEET MASS BALANCE MODEL

We used the spreadsheet mass balance model previously described with the vector proportions derived in this study to estimate concentrations that might occur in wastewater, solids, and product from a mill recycling RFID tagged OCC. The input parameters for the model, most of which were the same as used in preliminary studies described previously, are summarized in Table 6.1.

Two other input parameters, in-stream dilution and wastewater treatment residuals generation rate, were derived from NCASI data defining the distribution of these parameters for recycled container and boxboard mills. For both parameters we used the lower 25th percentile values (i.e., 25% of mills would have lower values). This is a more conservative choice than, for example, using the median (50th percentile) because lower values for these parameters cause the model to calculate higher concentrations of silver in residuals and at the edge of the receiving water mixing zone.

Table 6.1 Spreadsheet Model General Input Parameters

General parameters	**Value**
Weight of box, pounds* =	1
Mass of silver per tag, grams =	0.0157
Percent of incoming boxes with chips attached* =	30%
Yield – tons of production per ton of recovered fiber at gate* =	90%
Weight of incoming recovered fiber, stpd =	500
Basis weight of final product, g/sq in. =	0.130
Percent of incoming metal that is directed to:	
Product	84%
Whitewater effluent	3.4%
Whitewater settled solids	8.9%
Screening/cleaning rejects	4.1%
* assumptions suggested by FBA in e-mail document received April 23, 2004	

Table 6.1 provides one set of general assumptions made about the RFID tags and OCC recycling mill operations. The general parameter values suggested by FBA can be adjusted to represent mill-specific operations. This study provided the relative percentage of silver found in each of the four process vectors shown in the four lower rows.

6.2 Example Comparison of Silver Concentrations to Regulatory Limits

Table 6.2 provides a comparison of the silver concentration associated with each vector estimated from the spreadsheet model to the appropriate water quality criteria, disposal limit, or product limit. A discussion for each vector follows. The number for the screening and cleaning rejects is zero because the majority of the fiber in the screening/cleaning unit operation is assumed to be recovered and becomes available for papermaking (described in Section 4.2.).

The "model percent of limit" value for the whitewater settled solids (using the lower 25th percentile solid waste generation rate described above) is derived by comparing the silver concentration in a toxicity characteristic leaching procedure (TCLP) extract of the solids to the TCLP limit for silver of 5 mg/L. This estimate may be high because in a full-scale operation, solids from the paper machine whitewater would likely be combined with other solids sent to the primary clarifier during papermaking and wastewater treatment.

The percent of limit value for the whitewater effluent is derived by comparing the estimated concentration of silver in clarified paper machine whitewater to the lowest Freshwater Water Quality Criterion for silver with the appropriate in-stream dilution. The percent of limit may also considered to be high because it is reasonable to assume that paper machine whitewater is likely to be combined with other flows and receive additional treatment prior to discharge as final effluent.

However, paper machine whitewater obtained from the pilot study does not reflect the potential accumulation of silver resulting from the recycling of whitewater carried out to varying degrees in most mill environments. As a result, the "percent of limit" for whitewater effluent, whitewater settled solids, and product obtained during the pilot study may be lower than would be encountered in full-scale operation.

Table 6.2 Output Vector Results Compared to Limits

Output Vector	Percent of Silver to Vector	Modeled Silver Concentration in Vector, ppm	Limit Value, ppm	Model Percent of Limit	Limit Type
Screening/cleaning rejects	4.1	0.0237[1]	5	0.47	TCLP[2]
Whitewater settled solids	8.9	0.0067[1]	5	0.13	TCLP[2]
Whitewater effluent	3.4	0.1751	0.0032	55[3]	WQC[4]
Product	84	9.65	0.30[5]	See note 6	ADI_{CSR}

[1] Modeled concentration, assumed 1% extraction efficiency based on conservative interpretation of preliminary TCLP study of wet ink.
[2] Maximum Concentration of Contaminants for the Toxicity Characteristic, 55 FR 11862, March 1990.
[3] Percent value incorporates lower 25th percentile for in-stream dilution.
[4] National Recommended Water Quality Ambient Criteria: 2002. EPA-822-R-02-047, November 2002.
[5] The chemical-specific acceptability daily intake based on the silver RfD, the ADI_{CSR}, is 0.30 mg/person/day (USEPA 2005). FDA does not establish numerical limits for silver.
[6] Extraction testing results indicate virtually no movement of silver from product sample into extraction solvents. Extraction results are shown in Appendix E.

Knowing from prior experience the immobility of silver and other metals in the paperboard matrix, extraction tests conducted according to the procedures in 21 CFR 176.170 (c) (USFDA 2004) were conducted using water as an extractant at 212ºF for 30 minutes and at 120ºF for 24 hours reflecting conditions B and E of Table 2 (in 21 CFR 176.170). The

results from the laboratory (Appendix E) indicated a silver concentration in the product (11 µg/kg) very similar to the product concentrations shown in Appendix C. Silver concentrations in the extractant were non-detect at a method reporting limit (MRL) of 0.0005 µg/sq. in or 4 parts per billion detectability level for a reported 0.13 g/sq.in paperboard. These results indicate the extraordinary resistance of the silver in the RFID ink to move from the substrate.

It should be noted that the particular combination of values shown in Tables 6.2 is directly related to the assumptions made in the spreadsheet model inputs shown in Table 6.1 (i.e., for a hypothetical mill). Adjusting input values in Table 6.1 to reflect site-specific conditions may result in significant changes in the vector silver concentrations and, therefore, changes to the "percent of limit" values in Table 6.2.

7.0 CONCLUSIONS

In response to questions about the environmental significance and product effects of RFID tags becoming part of the OCC recycle stream, NCASI used a mass balance spreadsheet model to conduct a desktop review. A preliminary study indicated that RFIDs utilizing laminated copper foil antennae maintained their integrity during pulping in a medium consistency hydrapulper (98% recovery) and were not likely to result in regulatory concerns.

Some RFIDs use conductive silver ink in antennae, and the fate of this silver in OCC recycling operations may be of potential concern. Because of considerable uncertainty in the partitioning of silver in the model output vectors, NCASI conducted a study to measure the partitioning of silver in a pilot plant set up to simulate, as closely as possible, OCC processing in a reasonable model mill situation. Unit operations were carried out at conditions (pressure, time, etc.) considered to be typical of industry operations. Two pilot plant runs were conducted: a baseline run with no RFIDs attached, and an RFID run.

Partitioning data from the pilot-plant runs were used with lower 25^{th} percentile values for residuals and wastewater generation rates to update NCASI's spreadsheet model to estimate concentrations that might occur in wastewater, solids, and product from a hypothetical mill recycling RFID tagged OCC. These concentrations were compared to appropriate water quality criteria, disposal limits, or product limits. The results indicate that with the input conditions used to run the spreadsheet model, no applicable regulatory limits would be exceeded.

8.0 POTENTIAL FUTURE RESEARCH

This study has identified several potentially useful areas where additional research could facilitate a better understanding of environmental and product quality issues related to the presence of RFID tags in the OCC recycle stream.

- Model validation – The NCASI spreadsheet mass balance model has not been validated. To do so would require sampling of one or more full-scale OCC operations preferably processing enough conductive silver ink RFIDs to make detection of silver in the various vectors feasible.

- Background silver – It is reasonable to assume that as RFID use becomes more prevalent, the background levels of silver in OCC will increase with time. It may be possible to model this background level increase using manufacturing and recycling statistics from FBA and/or American Forest and Paper Association (AF&PA).

- Paper machine whitewater obtained from the pilot study does not reflect the potential accumulation of silver resulting from the recycling of whitewater carried out to varying degrees in most mill environments. As a result, concentrations of silver in the whitewater obtained during the pilot study may be lower than would be encountered in full-scale operation. However, it may be possible to estimate the whitewater concentration using information on the degree and methods of whitewater recycling at a particular facility.

9.0 REFERENCES

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APPENDIX A

PRELIMINARY STUDY TO EVALUATE FATE OF COPPER FOIL RFIDS

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FROM: Van Maltby, Jay Unwin

DATE: October 18, 2004

SUBJECT: Preliminary Study to Evaluate Fate of Copper Foil RFIDs

On Friday, October 15th, NCASI conducted a preliminary study to determine the fate of RFIDs with copper foil antennae during hydrapulping at Western Michigan University's Pilot Plant. Three hundred copper foil Alien® RFIDs (Printronix®) were attached to 300 lbs of OCC and pulped under typical conditions in the medium consistency hydrapulper. After pulping, the stock was pumped through the extraction plate (0.625" holes) and the RFIDs recovered. While the adhesive paper backing attached to each RFID was lost during pulping, the RFID antennae/chip units remained intact with the copper foil antennae sandwiched between two plastic layers. Of the 300 RFIDs loaded into the hydrapulper, 294 (98 percent) were recovered. The remaining six were assumed to have either passed through the extraction plate or were attached to the bottom of the hydrapulper rotor. During subsequent cleaning of the hydrapulper, at least two intact RFIDs were seen in the tank but were not recoverable. One of the 294 RFIDs recovered had lost its printed circuit chip during pulping. None of the copper foil antennae recovered had any tears or evidence of missing copper. Multiple samples of the pulp were run through a Summerville 6-cut slotted screen. No visible evidence of any copper was observed in the pulp samples. Photos 1 and 2 show both the original RFID format and the recovered RFIDs.

A second study was conducted in a Morden Slush Maker which simulates low consistency, high shear pulping. This unit pulps four pound batches of OCC under lower consistency, higher shear, and higher temperature conditions. The initial pulping temperature is 39º C and rises to approximately 50º C during pulping. Because NCASI expected this device to shred the RFIDs, extra RFIDs were added to the batch to allow for easier examination of the pulp for copper. Ten of the 18 RFIDs added were recovered and the remaining 8 were inadvertently poured down the drain. Of the 10 recovered, all ten foil antennae were intact although all 10 printed circuit chips were stripped from the RFIDs. Multiple samples of the pulp were run through a Summerville 6-cut slotted screen. No visible evidence of any copper was observed in the pulp samples. The study was repeated on a second

Morden Slush Maker under similar conditions. All of the RFIDs added were recovered, although one of the copper foil antennae was torn into several pieces (4-5 cm length.) All of the RFIDs lost the printed circuit chips. Photo 3 shows the recovered RFIDs from the low consistency, high shear runs.

The study concludes that currently available Alien Printronix® copper foil antenna RFIDs adhesively attached to OCC maintain their integrity during pulping in WMU's medium consistency hydrapulper. Under simulated higher shear conditions, the foil antennae remain essentially intact although the printed circuit components were stripped from the RFIDs.

Photo 1 Close-up of New RFID and Recovered RFIDs

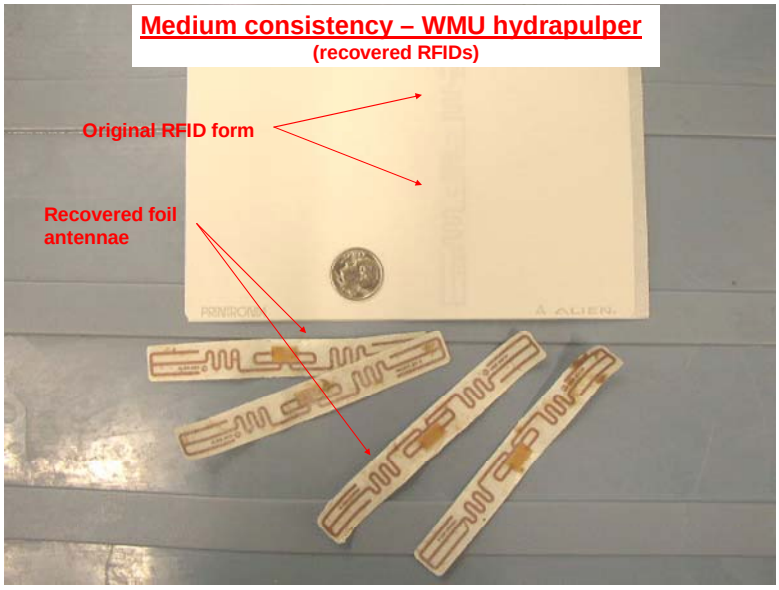
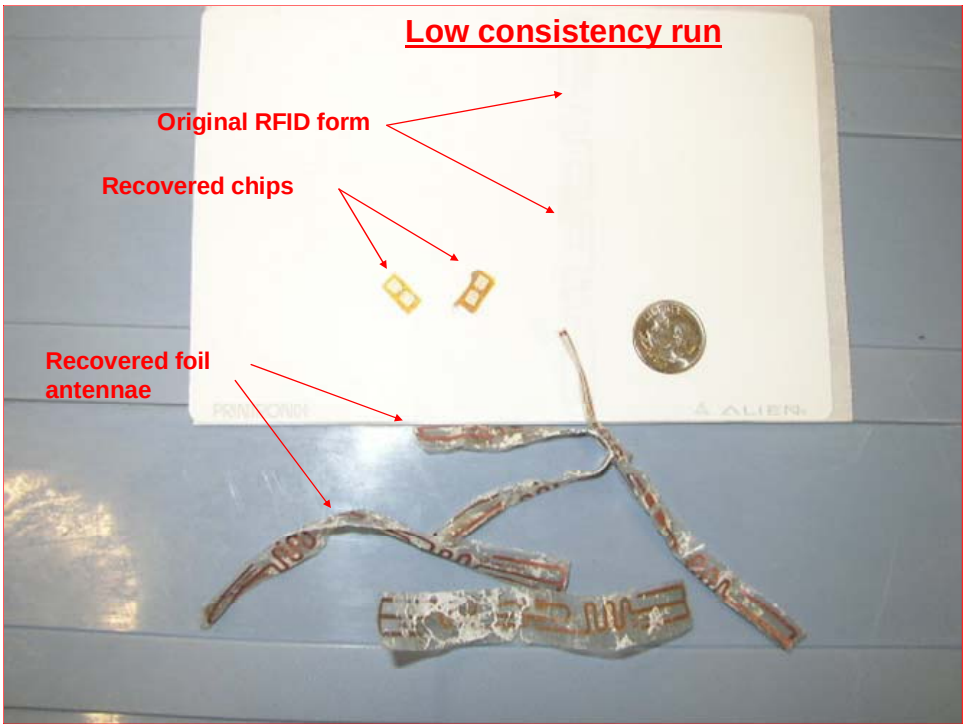


Photo 2 Recovered RFIDs from WMU Hydrapulper

Photo 3 **Close up of Recovered RFIDs from Low Consistency Pulping**



APPENDIX B

DESCRIPTION OF UNIT OPERATIONS

AND SAMPLING PROCEDURES

B1. Sampling Process Design

This study will examine the environmental and product quality implications of silver in recycling OCC containing RFIDs. It will examine the silver concentration in four output vectors that include pulp washing and cleaning (rejects), primary sludge, primary effluent, and product as generated from PP unit operations under steady state conditions.

Critical samples include samples for silver analysis of pulp, screening and cleaning rejects, clarified whitewater, whitewater solids, and product. Additional critical determinations include quantification (volume) and production of the samples mentioned above under steady state conditions. Other non-critical determinations will be made in the PP during the research. Non-critical determinations include hydrapulper pulp temperature, ORP, pH, and other general water quality chemical parameters. These data will be used to support the critical data.

B2. Sampling Methods

Because each unit operation is a batch process, samples will be collected only after a pre-determined amount of time has passed and the equipment is assumed to be operating at steady state conditions. The amount of time for each unit operation to reach steady state operation will be determined by PP personnel. While the sampling details will change slightly between different unit operations due to uniqueness in equipment and associated plumbing, the sample collection strategy is similar for all unit operations and is described by unit operation below.

Individual archival samples of outputs will be collected from various unit operations and stored by NCASI in the event that additional unanticipated information is needed.

Hydrapulper – To account for fiber losses associated with each of the unit operations, each run (with and without RFIDs) will require 600 lbs of fiber to pass through the system in order to provide sufficient fiber to make board at the paper machine. Two 300 lb hydrapulper batches will be prepared under typical conditions (water only, steam heat to 130ºF). At the end of each pulping batch, the pulp will be pumped through the extraction plate into stock chest 5. Samples will be collected from stock chest 5 along with measurements of consistency, temperature and pH and others given in Table B5. Any rejects remaining in the hydrapulper will be quantified and a representative sample will be collected.

If it is necessary to recover hydrapulper rejects, access to the extraction plate will require physical entry to the hydrapulper, and appropriate electrical lockouts and confined work space entry requirements will be followed.

Screening and Cleaning Unit Operations

Each of the five screening and cleaning unit operations will be operated as batch processes. The accepts (pulp) from one stage will be the feed to the next stage. Pulp will be temporarily stored in stock chests between stages. Rejects will likely be generated for each of the five stages. While the rejects from each process will be quantified separately, samples will be obtained from a composite made from volume proportional amounts of rejects from each state.

Primary Coarse screen (0.079") and Primary Fine screen (0.014") – Pulp will be processed through each of these screens as separate (batch) unit operations. Initially, pulp will be pumped from stock chest 5 through the primary coarse screen. Accepts will go to stock chest 4 and rejects will go to stock chest 2. Prior to steady state conditions, all rejects will be discarded. After steady state conditions are achieved (approximately 1 minute or less as determined by PP personnel), the reject

samples will be collected in stock chest 2. A stopwatch will be used to determine steady state run time. At the end of the batch, the rejects in stock chest 2 will be completely mixed and quantified. Sampling will include a 5-gal (pre-cleaned bucket) archival sample, and a representative sample will be collected in a 30-gallon barrel to be composited later.

At the end of the batch, pulp will be returned to stock chest 5 and the entire process will be repeated using the primary fine screen. Appropriate pulp volume measurements will be made to account for losses during pulp transfer. Samples will be collected in the same manner as described above for the primary coarse screen. At the end of this batch, the pulp (accepts) will be in stock chest 4.

Primary and Secondary Forward cleaners – Pulp will be pumped from stock chest 4 into the bank of forward cleaners. Accepts will go to stock chest 5 and rejects will go to the secondary reject tank. Prior to steady state conditions, all rejects will be sewered by keeping the ball valve at the bottom of the secondary reject tank open allowing the rejects to flow to the floor drain. After steady state conditions are achieved (approximately 1 minute or less as determined by PP personnel), the valve will be closed and all of the reject samples will be collected in the secondary reject tank. A stopwatch will be used to determine steady state operation time. At the end of the batch, the rejects will be completely mixed, quantified, and sampled as described in Appendix B. Sampling will include a 5-gal (pre-cleaned bucket) archival sample, and a representative sample will be collected in a 30-gallon barrel to be composited later. At the end of the batch the pulp (accepts) will be returned to stock chest 4. Appropriate pulp volume measurements will be made to account for losses during pulp transfer.

P-1 and P-2 Reverse cleaners – Pulp will be processed through the banks of reverse cleaners as two separate (batch) unit operations. Pulp will be pumped from stock chest 4 through the reverse cleaners. Accepts will go to stock chest 5 and rejects will go the primary reject tank (secondary cleaner tank). Prior to steady state conditions, all rejects will be sewered by keeping the ball valve at the bottom of the primary reject tank (secondary cleaner tank) open allowing the rejects to flow to the u-drain in the floor. After steady state conditions are achieved (approximately 1 minute or less as determined by PP personnel), the valve will be closed and all of the reject samples will be collected and quantified in the primary reject tank (secondary cleaner tank. A stopwatch will be used to determine steady state operation time. Sampling will include a 5-gal (pre-cleaned bucket) archival sample, and a representative sample will be collected in a 30-gallon barrel to be composited later.

At the end of the batch the pulp (accepts) will be returned to stock chest 4. Appropriate pulp volume measurements will be made to account for losses during pulp transfer. The entire unit operation will be repeated (as P-2 reverse cleaners). Samples will be collected in the same manner as described above for the P-1 reverse cleaners. At the end of this batch, the pulp (accepts) will be in stock chest 5.

Screening and Cleaning Stage Reject Compositing and Archival Sampling

Rejects from each of the five 30-gal barrels (five screening and cleaning unit operations) will be composited in a volume proportionate manner into a single barrel. The archival samples collected in the 5-gallon buckets will be saved for potential use.

Paper Machine Sampling – After the pulp cleaning unit operations are completed, the remaining pulp will be sent to the paper machine for board production from stock chest 5. During this unit operation, steady state samples of product (board), whitewater settled solids (sludge), and clarified whitewater will be collected. Descriptions for each vector are below.

It is difficult to estimate with accuracy the amount of pulp remaining after screening and cleaning unit operations, and therefore, the amount of time that the paper machine will be operated. At a minimum,

the machine needs to be operated for 20 minutes in order to reach steady state conditions. If there is a significant amount of pulp remaining, we may chose to operate the machine to reach steady state and collect the board and whitewater for a limited additional amount of time, e.g., 20 minutes. After that time, the PP operators may chose to continue operation of the paper machine to manage the remaining pulp, although the board and whitewater would no longer be quantified.

Board Production – Board will be produced from the pulp at a pre-determined basis weight and moisture typical of the industry. Prior to steady state conditions, board will be produced on the end roll but not quantified. After steady state conditions are achieved (approximately 20 minutes), the board produced will be tagged with a colored strip of paper as the starting point and production will continue for a minimum of 20 additional minutes. At the endpoint, the roll will be tagged with a colored strip of paper as the endpoint. The run time between the starting point and the end point will be recorded with a stopwatch.

After the board production is complete, the outermost layers of the board on the roll (after the stop time) will be removed. The middle layer (board produced between the start point and the stop point) will be removed and separated for sampling.

Whitewater Sample and Whitewater Solids Collection – Prior to steady state conditions, all whitewater will be sewered using the paper machine whitewater collection and sewer system. After steady state conditions are achieved (approximately 20 minutes) the whitewater drain on the paper machine will be closed and whitewater will be pumped from the 2 cubic foot drain with a submersible sump pump (Barnes Model SP33VF) to the back chest. Whitewater will be collected in the back chest for the same duration as the start and stop time used for the board production. After reaching the stop time for the board production, the submersible pump will be turned off and the whitewater drain on the paper machine will be reopened to allow additional whitewater produced to flow into the floor drain.

During the whitewater collection period, the whitewater collected in the back chest will be mixed using the chest mixer. At the end of the collection period, the whitewater in the back chest will be quantified using tank geometry and water level. After quantification, a portion will be transferred to a settling column (8 feet tall, 6” diameter). The whitewater will be allowed to settle. The height of the liquid/solids interface will be recorded for up to a three hour time period. Whitewater solids will be drawn from the bottom of the column and clarified whitewater will be drawn from the uppermost portion of the column.

B3. Sample Handling and Custody

Sample bottles - Pre-cleaned sample bottles of a sufficient volume will be provided by the laboratory. Bottles will have a semi-wide or wide mouth to accommodate slurried, semi-solid, and solid sample matrices. Samples collected during each batch will be stored on-site for the duration of the day until all samples have been collected. After each batch is completed, samples will be stored in coolers with ice for transport to the laboratory.

Sample buckets and barrels – Archival samples of screening and cleaning rejects will be stored in new pre-cleaned laboratory buckets with a locking seal lid. Buckets and barrels used for reject compositing will be cleaned in the laboratory using the following procedure.

1. Clean the equipment in a reasonably clean and low metals level environment if possible.
2. Use non-talc gloves and non-metallic tongs for handling the equipment.

3. Soak/wet the insides of the buckets and lids in a 0.5% solution of liquid detergent (e.g., Alconox, Liquinox) for > 30 minutes. Rinse equipment in deionized water (DIW) until there is no sign of detergent residue.
4. Soak/wet the insides of the buckets, barrels, and lids with room-temperature nitric acid (pH<2) for >2 hours. Rinse in DIW.
5. Soak/wet in 1 N trace-metal grade HCL for > 2 hours. Rinse in DIW.
6. Air dry the buckets and temporarily close with lids.

Sample filtration – None needed.

Sample preservation – Samples will be acidified upon receipt using (1+1) nitric acid to pH<2 (as described in Method 200.8).

Sample holding time – Samples may be held for up to two (2) weeks without preservation, 6 months with preservation.

Chain of custody – A chain of custody form will be filled out for the samples to be submitted to the analytical laboratory for silver analysis. A unique identification code will be assigned to each sample along with the sample dates and the initials of the individual collecting the sample.

APPENDIX C

ANALYTICAL PROCEDURES AND DATA

Modified Digestion Procedures Used for Silver Analysis of NRC Study Samples (NCASI)

Solid Samples:

0.5 g sample, add 30 mL deionized water in glass beaker

Add 20 mL conc. nitric acid, heat at ~95°C for 5-6 hours, cool, add 10 mL conc. nitric acid, let sit overnight

Heat at ~95°C for 2 hours, cool

Add 2.5 mL 30% hydrogen peroxide, heat at ~95°C for 1 hour, cool

Filter and dilute to 50 mL with deionized water

Aqueous Samples:

25 mL sample

Add 20 mL conc. nitric acid, heat at ~95°C for 5-6 hours, cool, add 10 mL conc. nitric acid, let sit overnight

Heat at ~95°C for 2 hours, cool

Add 2.5 mL 30% hydrogen peroxide, heat at ~95°C for 1 hour, cool

Filter and dilute to 50 mL with deionized water

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Hydrapulper Baseline	Aqueous	RFB-1HP-01	No	N	0.0014	0.0014	0.0014	mg/L	EPA 200.8	122% recovery of a 2.68 mg silver (from tag) spike
Hydrapulper Baseline	Aqueous	RFB-1HP-02	No	N	0.0232	0.0232	0.0232	mg/L	EPA 200.7	
Hydrapulper Baseline	Aqueous	RFB-1HP-03	No	N	0.0017	0.0017	0.0017	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-04	No	N	0.0015	0.0015	0.0015	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-05	No	N	0.001	0.001	0.001	mg/L	EPA 200.8	105.2% recovery of a 0.1766 mg silver (from tag) spike
Hydrapulper Baseline	Aqueous	RFB-1HP-06	No	N	0.0022	0.0022	0.0022	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-07	No	N	0.0016	0.0016	0.0016	mg/L	EPA 200.8	126.6 % recovery of a 0.1766 mg silver (from tag) spike
Hydrapulper Baseline	Aqueous	RFB-1HP-08	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-09	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-10	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-11	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-12	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-13	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-14	No	N	0.001	0.001	0.001	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-15	No	N	0.0017	0.0017	0.0017	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-16	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-17	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-18	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-19	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-20	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-21	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-22	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-23	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-24	No	N	0.0014	0.0014	0.0014	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-25	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-26	No	N	0.0015	0.0015	0.0015	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-27	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-28	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper Baseline	Aqueous	RFB-1HP-29	Yes	Y	0.001	0.0005	0	mg/L	EPA 200.8	
Hydrapulper RFID	Aqueous	RFT-1HP-01	No	N	0.496	0.496	0.496	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-02	No	N	0.543	0.543	0.543	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-03	No	N	0.362	0.362	0.362	mg/L	EPA 200.7	

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Hydrapulper RFID	Aqueous	RFT-1HP-04	No	N	0.515	0.515	0.515	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-05	No	N	0.391	0.391	0.391	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-06	No	N	0.308	0.308	0.308	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-07	No	N	0.391	0.391	0.391	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-08	No	N	0.309	0.309	0.309	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-09	No	N	0.438	0.438	0.438	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-10	No	N	0.582	0.582	0.582	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-11	No	N	0.665	0.665	0.665	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-12	No	N	0.443	0.443	0.443	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-13	No	N	0.54	0.54	0.54	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-14	No	N	0.448	0.448	0.448	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-15	No	N	0.478	0.478	0.478	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-16	No	N	0.294	0.294	0.294	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-17	No	N	0.396	0.396	0.396	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-18	No	N	0.34	0.34	0.34	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-19	No	N	0.313	0.313	0.313	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-20	No	N	0.408	0.408	0.408	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-21	No	N	0.51	0.51	0.51	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-22	No	N	0.305	0.305	0.305	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-23	No	N	0.542	0.542	0.542	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-24	No	N	0.204	0.204	0.204	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-25	No	N	0.595	0.595	0.595	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-26	No	N	0.658	0.658	0.658	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-27	No	N	0.528	0.528	0.528	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-28	No	N	0.362	0.362	0.362	mg/L	EPA 200.7	
Hydrapulper RFID	Aqueous	RFT-1HP-29	No	Y	0.421	0.421	0.421	mg/L	EPA 200.7	
Cleaning/screening Baseline	Aqueous	RFB-2CS-01	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-02	No	N	0.0011	0.0011	0.0011	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-03	No	N	0.0054	0.0054	0.0054	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-04	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-05	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-06	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-07	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Cleaning/screening Baseline	Aqueous	RFB-2CS-08	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-09	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-10	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-11	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-12	No	N	0.0029	0.0029	0.0029	mg/L	EPA 200.8	114.4% recovery of a 0.1766 mg silver (from tag) spike
Cleaning/screening Baseline	Aqueous	RFB-2CS-13	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-14	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-15	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-16	No	N	0.0021	0.0021	0.0021	mg/L	EPA 200.8	113.8% recovery of a 0.1766 mg silver (from tag) spike
Cleaning/screening Baseline	Aqueous	RFB-2CS-17	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-18	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-19	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-20	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-21	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-22	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-23	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-24	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-25	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-26	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-27	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-28	No	N	0.0019	0.0019	0.0019	mg/L	EPA 200.8	
Cleaning/screening Baseline	Aqueous	RFB-2CS-29	No	Y	0.0013	0.0013	0.0013	mg/L	EPA 200.8	
Cleaning/screening RFID	Aqueous	RFT-2CS-01	No	N	0.096	0.096	0.096	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-02	No	N	0.496	0.496	0.496	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-03	No	N	0.084	0.084	0.084	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-04	No	N	0.627	0.627	0.627	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-05	No	N	0.42	0.42	0.42	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-06	No	N	0.688	0.688	0.688	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-07	No	N	0.411	0.411	0.411	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-08	No	N	0.345	0.345	0.345	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-09	No	N	0.71	0.71	0.71	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-10	No	N	0.857	0.857	0.857	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-11	No	N	0.69	0.69	0.69	mg/L	EPA 200.7	

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Cleaning/screening RFID	Aqueous	RFT-2CS-12	No	N	0.656	0.656	0.656	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-13	No	N	0.734	0.734	0.734	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-14	No	N	0.671	0.671	0.671	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-15	No	N	0.699	0.699	0.699	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-16	No	N	0.449	0.449	0.449	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-17	No	N	0.602	0.602	0.602	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-18	No	N	0.609	0.609	0.609	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-19	No	N	0.566	0.566	0.566	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-20	No	N	0.577	0.577	0.577	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-21	No	N	0.43	0.43	0.43	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-22	No	N	0.494	0.494	0.494	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-23	No	N	0.686	0.686	0.686	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-24	No	N	0.673	0.673	0.673	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-25	No	N	0.595	0.595	0.595	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-26	No	N	0.638	0.638	0.638	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-27	No	N	0.878	0.878	0.878	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-28	No	N	0.59	0.59	0.59	mg/L	EPA 200.7	
Cleaning/screening RFID	Aqueous	RFT-2CS-29	No	Y	0.713	0.713	0.713	mg/L	EPA 200.7	
Whitewater eff. Baseline	Aqueous	RFB-3WE-01	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-02	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	91.8% recovery of a 0.1766 mg silver (from tag) spike
Whitewater eff. Baseline	Aqueous	RFB-3WE-03	No	N	0.0047	0.0047	0.0047	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-04	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	149.5% recovery of a 0.1766 mg silver (from tag) spike
Whitewater eff. Baseline	Aqueous	RFB-3WE-05	No	N	0.0057	0.0057	0.0057	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-06	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-07	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-08	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-09	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-10	No	N	0.001	0.001	0.001	mg/L	EPA 200.8	105.6% recovery of a 0.1766 mg silver (from tag) spike
Whitewater eff. Baseline	Aqueous	RFB-3WE-11	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-12	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-13	No	N	0.0011	0.0011	0.0011	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-14	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-15	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Whitewater eff. Baseline	Aqueous	RFB-3WE-16	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-17	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-18	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-19	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-20	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	'143.3% recovery of a 0.1766 mg silver (from tag) spike
Whitewater eff. Baseline	Aqueous	RFB-3WE-21	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-22	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-23	No	N	0.015	0.015	0.015	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-24	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-25	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-26	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-27	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-28	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. Baseline	Aqueous	RFB-3WE-29	Yes	Y	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-01	No	N	0.0066	0.0066	0.0066	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-02	No	N	0.0151	0.0151	0.0151	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-03	No	N	0.0068	0.0068	0.0068	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-04	No	N	0.009	0.009	0.009	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-05	No	N	0.0058	0.0058	0.0058	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-06	No	N	0.0057	0.0057	0.0057	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-07	No	N	0.006	0.006	0.006	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-08	No	N	0.0058	0.0058	0.0058	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-09	No	N	0.0062	0.0062	0.0062	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-10	No	N	0.0071	0.0071	0.0071	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-11	No	N	0.0075	0.0075	0.0075	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-12	No	N	0.0066	0.0066	0.0066	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-13	No	N	0.0071	0.0071	0.0071	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-14	No	N	0.007	0.007	0.007	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-15	No	N	0.008	0.008	0.008	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-16	No	N	0.0066	0.0066	0.0066	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-17	No	N	0.0069	0.0069	0.0069	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-18	No	N	0.0065	0.0065	0.0065	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-19	No	N	0.0066	0.0066	0.0066	mg/L	EPA 200.8	

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Whitewater eff. RFID	Aqueous	RFT-3WE-20	No	N	0.0122	0.0122	0.0122	mg/L	EPA 200.7	
Whitewater eff. RFID	Aqueous	RFT-3WE-21	No	N	0.0127	0.0127	0.0127	mg/L	EPA 200.7	
Whitewater eff. RFID	Aqueous	RFT-3WE-22	No	N	0.0074	0.0074	0.0074	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-23	No	N	0.0071	0.0071	0.0071	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-24	No	N	0.0074	0.0074	0.0074	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-25	No	N	0.0061	0.0061	0.0061	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-26	No	N	0.0088	0.0088	0.0088	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-27	No	N	0.0075	0.0075	0.0075	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-28	No	N	0.0065	0.0065	0.0065	mg/L	EPA 200.8	
Whitewater eff. RFID	Aqueous	RFT-3WE-29	No	Y	0.0062	0.0062	0.0062	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-01	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-02	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-03	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-04	No	N	0.0022	0.0022	0.0022	mg/L	EPA 200.8	'138.1% recovery of a 0.1766 mg silver (from tag) spike
Whitewater solids Baseline	Aqueous	RFB-4WS-05	No	N	0.0012	0.0012	0.0012	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-06	No	N	0.0019	0.0019	0.0019	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-07	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-08	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-09	No	N	0.0057	0.0057	0.0057	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-10	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-11	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-12	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-13	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-14	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	'174.3% recovery of a 0.1766 mg silver (from tag) spike
Whitewater solids Baseline	Aqueous	RFB-4WS-15	No	N	0.0023	0.0023	0.0023	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-16	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-17	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-18	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-19	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-20	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-21	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-22	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-23	No	N	0.0014	0.0014	0.0014	mg/L	EPA 200.8	

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Whitewater solids Baseline	Aqueous	RFB-4WS-24	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-25	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	'117.1% recovery of a 0.1766 mg silver (from tag) spike
Whitewater solids Baseline	Aqueous	RFB-4WS-26	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-27	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-28	Yes	N	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids Baseline	Aqueous	RFB-4WS-29	Yes	Y	0.001	0.0005	0	mg/L	EPA 200.8	
Whitewater solids RFID	Aqueous	RFT-4WS-01	No	N	0.0613	0.0613	0.0613	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-02	No	N	0.0633	0.0633	0.0633	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-03	No	N	0.0663	0.0663	0.0663	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-04	No	N	0.0604	0.0604	0.0604	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-05	No	N	0.0573	0.0573	0.0573	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-06	No	N	0.0644	0.0644	0.0644	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-07	No	N	0.061	0.061	0.061	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-08	No	N	0.0701	0.0701	0.0701	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-09	No	N	0.0692	0.0692	0.0692	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-10	No	N	0.0725	0.0725	0.0725	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-11	No	N	0.0615	0.0615	0.0615	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-12	No	N	0.0575	0.0575	0.0575	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-13	No	N	0.0632	0.0632	0.0632	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-14	No	N	0.0632	0.0632	0.0632	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-15	No	N	0.0617	0.0617	0.0617	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-16	No	N	0.0645	0.0645	0.0645	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-17	No	N	0.0695	0.0695	0.0695	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-18	No	N	0.0716	0.0716	0.0716	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-19	No	N	0.0658	0.0658	0.0658	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-20	No	N	0.0655	0.0655	0.0655	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-21	No	N	0.0656	0.0656	0.0656	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-22	No	N	0.061	0.061	0.061	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-23	No	N	0.0647	0.0647	0.0647	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-24	No	N	0.0633	0.0633	0.0633	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-25	No	N	0.0675	0.0675	0.0675	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-26	No	N	0.0607	0.0607	0.0607	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-27	No	N	0.0732	0.0732	0.0732	mg/L	EPA 200.7	

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Whitewater solids RFID	Aqueous	RFT-4WS-28	No	N	0.0653	0.0653	0.0653	mg/L	EPA 200.7	
Whitewater solids RFID	Aqueous	RFT-4WS-29	No	Y	0.0625	0.0625	0.0625	mg/L	EPA 200.7	
Paper Machine Baseline	Solid	RFB-5PM-01	Yes	N	0.5	0.25	0	mg/kg	EPA 6010B	
Paper Machine Baseline	Solid	RFB-5PM-02	Yes	N	0.5	0.25	0	mg/kg	EPA 6010B	'98.9% recovery of a 0.1766 mg silver (from tag) spike
Paper Machine Baseline	Solid	RFB-5PM-03	Yes	N	0.5	0.25	0	mg/kg	EPA 6010B	
Paper Machine Baseline	Solid	RFB-5PM-04	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	'96.12% recovery of a 0.1766 mg silver (from tag) spike
Paper Machine Baseline	Solid	RFB-5PM-05	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-06	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-07	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-08	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-09	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-10	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-11	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-12	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-13	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-14	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	119.2% recovery of a 0.1766 mg silver (from tag) spike
Paper Machine Baseline	Solid	RFB-5PM-15	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-16	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-17	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-18	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-19	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-20	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	114.9% recovery of a 0.1766 mg silver (from tag) spike
Paper Machine Baseline	Solid	RFB-5PM-21	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-22	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-23	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-24	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-25	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-26	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-27	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-28	Yes	N	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine Baseline	Solid	RFB-5PM-29	Yes	Y	0.5	0.25	0	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-01	No	N	15.3	15.3	15.3	mg/kg	EPA 6010B	
Paper Machine RFID	Solid	RFT-5PM-02	No	N	14.4	14.4	14.4	mg/kg	EPA 6010B	

Location Run	Matrix	ID	ND	DUP	DL	HALFDL	DL0	Units	Method	Comment
Paper Machine RFID	Solid	RFT-5PM-03	No	N	13.4	13.4	13.4	mg/kg	EPA 6010B	
Paper Machine RFID	Solid	RFT-5PM-04	No	N	9.2	9.2	9.2	mg/kg	EPA 6010B	
Paper Machine RFID	Solid	RFT-5PM-05	No	N	8.1	8.1	8.1	mg/kg	EPA 6010B	
Paper Machine RFID	Solid	RFT-5PM-06	No	N	19.6	19.6	19.6	mg/kg	EPA 6010B	
Paper Machine RFID	Solid	RFT-5PM-07	No	N	7.4	7.4	7.4	mg/kg	EPA 6010B	
Paper Machine RFID	Solid	RFT-5PM-08	No	N	11.4	11.4	11.4	mg/kg	EPA 6010B	
Paper Machine RFID	Solid	RFT-5PM-09	No	N	9.7	9.7	9.7	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-10	No	N	10.6	10.6	10.6	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-11	No	N	13.9	13.9	13.9	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-12	No	N	16.7	16.7	16.7	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-13	No	N	8.8	8.8	8.8	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-14	No	N	10	10	10	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-15	No	N	11.7	11.7	11.7	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-16	No	N	14.6	14.6	14.6	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-17	No	N	11.3	11.3	11.3	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-18	No	N	8.8	8.8	8.8	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-19	No	N	8	8	8	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-20	No	N	13.2	13.2	13.2	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-21	No	N	13.8	13.8	13.8	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-22	No	N	9.9	9.9	9.9	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-23	No	N	16.1	16.1	16.1	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-24	No	N	11.2	11.2	11.2	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-25	No	N	13.7	13.7	13.7	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-26	No	N	28.4	28.4	28.4	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-27	No	N	11.6	11.6	11.6	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-28	No	N	11.5	11.5	11.5	mg/kg	EPA 6020	
Paper Machine RFID	Solid	RFT-5PM-29	No	Y	9.8	9.8	9.8	mg/kg	EPA 6020	

APPENDIX D

CALCULATION OF SILVER DISTRIBUTION ACROSS PROCESS VECTORS

The steady state distribution of RFID silver in the output vectors of the RFID run was calculated in several steps. Because the screening/cleaning and papermaking processes were not continuous (i.e., both processes were operated in batch mode, where screening/cleaning was conducted first, and then a portion of the S/C accepts was run on the paper machine), the relative proportions of silver in the output vectors of each process were estimated separately, and then were combined mathematically using the following formula:

$$F_a + F_b(F_c + F_d + F_e) = 1 \qquad \text{(Equation 1)}$$

where

F_a = the fraction of silver entering screening/cleaning that goes to rejects at steady state;
F_b = the fraction of silver entering screening/cleaning that goes to accepts at steady state;
F_c = the fraction of silver entering papermaking in screening/cleaning accepts that goes to product at steady state;
Fd = the fraction of silver entering papermaking in screening/cleaning accepts that goes to WW solids at steady state;
Fe = the fraction of silver entering papermaking in screening/cleaning accepts that goes to WW effluent at steady state;

All other steady state losses (e.g., silver volatilization or partitioning to equipment) are assumed to be 0.

This equation is a combination of two proportion equations, one for each batch process (i.e., screening/cleaning and papermaking). For screening/cleaning, in which there were two output vectors (accepts and rejects), the equation is

$$F_a + F_b = 1$$

For papermaking, with three output vectors (product, WW solids, and WW effluent), the equation is

$$F_c + F_d + F_e = 1$$

Steady state silver fractions (i.e., the "F" values) for each batch process were calculated as follows. First, the steady state concentration of silver in each vector from the baseline run was subtracted from the concentrations obtained from the RFID run to yield a steady state concentration of RFID silver in each vector. Second, the steady state mass of RFID silver in each vector was calculated from the observed concentration and the associated vector volume (for screening/cleaning rejects, PM whitewater effluent, and PM whitewater solids vectors) or mass (for the product vector). The fraction of silver in each vector for each batch process was determined as

$$F_{i,j} = M_{i,j}/M_{total,j}$$

where

$F_{i,j}$ is the steady state silver fraction in output vector i for batch process j,
$M_{i,j}$ is the steady state silver mass in vector i for batch process j, and
$M_{total,j}$ is the sum of the steady state silver masses of all output vectors for batch process j.

The silver concentration in the cleaning stage accepts matrix was not measured directly, but was estimated by difference using hydrapulper and screening/cleaning rejects data adjusting for non-steady state "losses" (material left in pipes, tanks, etc.) during screening/cleaning.

In summary, the steady state silver distribution was estimated from measured silver concentrations and vector volumes/masses as follows:

1. The distribution of RFID silver mass between S/C accepts and rejects generated at steady state was determined (F_a and F_b).
2. The distribution of RFID silver mass between the three paper machine output vectors generated at steady state was determined (F_c, F_d, F_e).
3. The combined steady state distribution of RFID silver in each output vector of interest (i.e., F_a, F_c, F_d, and F_e simulating a continuous screening/cleaning and papermaking process) was determined using Equation 1. Because an unrepresentatively large amount of fiber occurred in the screening/cleaning rejects as discussed in Section 4.2, silver distribution was also estimated using an assumed value of 0.045 (4.5% loss to rejects) for F_a.

APPENDIX E

SILVER MIGRATION TESTING PERFORMED BY COLUMBIA ANALYTICAL SERVICES

8540 Baycenter Road Jacksonville,Florida 32256 (904) 739-2277 (904) 739-2011 fax

Columbia Analytical Services INC.
An Employee - Owned Company

May 26, 2005 Service Request No: J0501960

Brian O'Banion
Fibre Box Association
2850 Golf Road
Rollin Meadows, FL 60008

RE: Migration testing - silver

Dear Brian:

Enclosed are the results of the sample(s) submitted to our laboratory on May 12, 2005. For your reference, these analyses have been assigned our service request number J0501960.

All analyses were performed according to our laboratory's quality assurance program. The test results meet requirements of the NELAP standards except as noted in the case narrative report. All results are intended to be considered in their entirety, and Columbia Analytical Services, Inc. (CAS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Please call if you have any questions. My extension is 289. You may also contact me via email at TKissinger@jax.caslab.com.

Respectfully submitted,

Columbia Analytical Services, Inc.

Tom Kissinger
Project Manager

Laboratory Manager: Greg Jordan
Quality Assurance Officer: Martha Montero

CAS Jacksonville is NELAC-accredited by the State of Florida, #E82502 valid through 6/30/05. Other state accreditations include: Arkansas, #88-0600 valid through 1/12/06; Georgia, #904 valid through 6/30/05; Louisiana, #02086 valid through 6/30/05; North Carolina, #527 valid through 12/31/05; and South Carolina, #96021 valid through 6/30/05.

Data Qualifiers

Inorganic Data

*	The result is an outlier. See case narrative.
#	The control limit criteria are not applicable. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result.
E	The result is an estimated amount because the value exceeded the instrument calibration range.
J	The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
U	The compound was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
Z	Too many colonies were present (TNTC). The numeric value represents the filtration volume.
i	The MRL/MDL has been elevated due to matrix interference.
X	See case narrative.

Metals Data

*	The result is an outlier. See case narrative.
#	The control limit criteria are not applicable. See case narrative.
B	The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
E	The reported value is estimated because of the presence of matrix interference.
M	The duplicate injection precision was not met.
N	The Matrix Spike sample recovery is not within control limits. See case narrative.
S	The result was determined by Method of Standard Additions (MSA).
U	The compound was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
W	The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
i	The MRL/MDL has been elevated due to matrix interference.
X	See case narrative.
+	The correlation coefficient for the MSA is less than 0.995.

Organic Data

*	The result is an outlier. See case narrative.
#	The control limit criteria are not applicable. See case narrative.
A	The tentatively identified compound is a suspected aldol-condensation product.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result.
C	The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
D	The reported result is from a dilution.
E	The result is an estimated amount because the value exceeded the instrument calibration range.
J	The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
N	The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P	The GC or HPLC confirmation criteria were exceeded. The relative percent difference is greater than 40% between the two analytical results (25% for CLP Pesticides)
U	The compound was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
i	The MRL/MDL has been elevated due to a chromatographic interference.
X	See case narrative.

Petroleum Hydrocarbon Specific

F	The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
L	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
H	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z	The chromatographic fingerprint does not resemble a petroleum product.

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

SAMPLE CROSS-REFERENCE

SAMPLE #	CLIENT SAMPLE ID	DATE	TIME
J0501960-001	Recycled Board FDA	05/10/05	0001
J0501960-002	Recycled Board Total	05/10/05	0001

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	Georgia Pacific Corporation	**Service Request:**	J0501960
Project:	Migration testing - silver	**Date Collected:**	5/10/2005
Sample Matrix:	Paperboard	**Date Received:**	5/12/2005

Total Metals

Sample Name:	Recycled Board Total	Units:	mg/Kg (ppm)
Lab Code:	J0501960-002	Basis:	NA
Test Notes:			

Analyte	Prep Method	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
Silver	EPA 3050B	6010B	0.50	1	5/23/2005	5/25/2005	11.2	

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	Georgia Pacific Corporation	**Service Request:**	J0501960
Project:	Migration testing - silver	**Date Collected:**	NA
Sample Matrix:	Paperboard	**Date Received:**	NA

Total Metals

Sample Name:	Method Blank	Units:	mg/Kg (ppm)
Lab Code:	J050523-MB	Basis:	NA
Test Notes:			

Analyte	Prep Method	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
Silver	EPA 3050B	6010B	0.50	1	5/23/2005	5/25/2005	U	

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	Georgia Pacific Corporation	**Service Request:**	J0501960
Project:	Migration testing - silver	**Date Collected:**	5/10/2005
Sample Matrix:	Paperboard	**Date Received:**	5/12/2005

FDA Migration Testing 21 CFR 176.170

Sample Name:	Recycled Board FDA	Units:	ug/sq in.
Lab Code:	J0501960-001	Basis:	NA
Test Notes:	Was extracted in water @212F for 30 Minutes		

Analyte	Prep Method	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
Silver	EPA 3020A	6020	0.0005	1	5/23/2005	5/24/2005	U	

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	Georgia Pacific Corporation	**Service Request:**	J0501960
Project:	Migration testing - silver	**Date Collected:**	NA
Sample Matrix:	Paperboard	**Date Received:**	NA

FDA Migration Testing 21 CFR 176.170

Sample Name:	Method Blank	Units:	ug/sq in.
Lab Code:	FDA BLK 30 MINUTE	Basis:	NA
Test Notes:	Was extracted in water @212F for 30 Minutes		

Analyte	Prep Method	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
Silver	EPA 3020A	6020	0.0005	1	5/23/2005	5/24/2005	U	

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	Georgia Pacific Corporation	**Service Request:**	J0501960
Project:	Migration testing - silver	**Date Collected:**	5/10/2005
Sample Matrix:	Paperboard	**Date Received:**	5/12/2005

FDA Migration Testing 21 CFR 176.170

Sample Name:	Recycled Board FDA	Units:	ug/sq in.
Lab Code:	J0501960-001	Basis:	NA
Test Notes:	Was extracted in water @120F for 24 Hours		

Analyte	Prep Method	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
Silver	EPA 3020A	6020	0.0005	1	5/23/2005	5/24/2005	U	

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	Georgia Pacific Corporation	**Service Request:**	J0501960
Project:	Migration testing - silver	**Date Collected:**	NA
Sample Matrix:	Paperboard	**Date Received:**	NA

FDA Migration Testing 21 CFR 176.170

Sample Name:	Method Blank	Units:	ug/sq in.
Lab Code:	FDA BLK 24 Hour	Basis:	NA
Test Notes:	Was extracted in water @120F for 24 Hours		

Analyte	Prep Method	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
Silver	EPA 3020A	6020	0.0005	1	5/23/2005	5/24/2005	U	

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	Georgia Pacific Corporation	**Service Request:**	J0501960
Project:	Migration testing - silver	**Date Collected:**	5/10/2005
Sample Matrix:	Paperboard	**Date Received:**	5/12/2005
		Date Extracted:	5/23/2005
		Date Analyzed:	5/25/2005

Matrix Spike Summary
Total Metals

Sample Name:	Recycled Board Total	Units:	mg/Kg (ppm)
Lab Code:	J0501960-002MS	Basis:	NA
Test Notes:			

Analyte	Prep Method	Analysis Method	MRL	Spike Level	Sample Result	Spiked Sample Result	Percent Recovery	CAS Percent Recovery Acceptance Limits	Result Notes
Silver	EPA 3050B	6010B	0.50	25	11.2	37.6	106	75-125	

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	Georgia Pacific Corporation	J0501960	**Service Request:** J2004398
Project:	Migration testing - silver		**Date Collected:** 5/10/2005
Sample Matrix:	Paperboard		**Date Received:** 5/12/2005
			Date Extracted: 5/23/2005
			Date Analyzed: 5/25/2005

Matrix Spike/Duplicate Matrix Spike Summary
Total Metals

Sample Name:	Recycled Board Total		Units: mg/Kg (ppm)
Lab Code:	J0501960-002MS	J0501960-002DMS	Basis: NA
Test Notes:			

				Spike Level		Sample	Spike Result		Percent Recovery			
Analyte	**Prep Method**	**Analysis Method**	**MRL**	MS	DMS	**Result**	MS	DMS	MS	DMS	CAS Acceptance Limits	**Relative Percent Difference**
Silver	EPA 3050B	6010B		25	25	11.2	37.6	37.5	106	105	75-125	<1

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client: Georgia Pacific Corporation
Project: Migration testing - silver
LCS Matrix: Paperboard

Service Request: J0501960
Date Collected: NA
Date Received: NA
Date Extracted: 5/23/2005
Date Analyzed: 5/25/2005

Laboratory Control Sample Summary
Total Metals

Sample Name: Lab Control Sample
Lab Code: J050523-LCS
Test Notes:

Units: mg/Kg (ppm)
Basis: NA

Analyte	Prep Method	Analysis Method	True Value	Result	Percent Recovery	CAS Percent Recovery Acceptance Limits	Result Notes
Silver	EPA 3050B	6010B	25	24.1	96	80-120	

T004542

Client Name: Georgia Pacific Corporation

Project Name: Migration testing - silver

Project Number:

Sample Group: Migration testing - silver

Project Manager: Sergio Galeano

Project Chemist: Tom Kissinger

CAS Location: Columbia Analytical Services, Inc.
8540 Baycenter Rd.
Jacksonville, FL
32256

QC Sample Containers:

This sample kit may contain additional sample containers that have been designated for laboratory Quality Control (QC). To comply with certification programs and to continue to provide you with high quality, legally-defensible data, Columbia Analytical Services monitors laboratory QC using field samples.

From your perspective, these QC samples are similar to field duplicates; however, the lab QC sample does not replace requirements for the field duplicates that may be a part of your sampling plan.

1. Fill all of the additional bottles from any sampling point of your choice.
2. Fill the sample label as you would for a normal sample.
3. Enter on the Chain of Custody the total number of containers collected from the sampling point(s) of choice and include the laboratory QC samples.

Please return this report along with the Chain of Custody or set of sampl

Columbia Analytical Services, Inc.
Cooler Receipt and Preservation Form

Client: GP Service Request # J6501960

Project: Migration

Cooler received on 5-12-05 and opened on 5-12-05 by IDS

COURIER: CAS UPS (FEDEX) DHL CLIENT Tracking #

1	Were custody seals on outside of cooler?	Yes	No	(N/A)
2	Were seals intact, signed and dated?	Yes	No	(N/A)
3	Were custody papers properly filled out?	(Yes)	No	N/A
4	Temperature of cooler(s) upon receipt (Should be 4 +/- 2 degrees C) N/A			
5	Correct Temperature?	Yes	No	(N/A)
6	Were Ice or Ice Packs present	Yes	No	(N/A)
7	Did all bottles arrive in good condition (unbroken, etc....)?	(Yes)	No	N/A
8	Were all bottle labels complete (sample ID, preservation, etc....)?	(Yes)	No	N/A
9	Did all bottle labels and tags agree with custody papers?	(Yes)	No	N/A
10	Were the correct bottles used for the tests indicated?	(Yes)	No	N/A
11	Were all of the preserved bottles received with the appropriate preservative?	Yes	No	(N/A)

HNO3 pH<2 H2SO4 pH<2 ZnAc2/NaOH pH>9 NaOH pH>12 HCl pH<2

Preservative additions noted below

12	Were all samples received within analysis holding times?	(Yes)	No	N/A
13	Were VOA vials checked for absence of air bubbles? If present, note below	Yes	No	(N/A)
14	Where did the bottles originate?	CAS	(Client)	

Sample ID	Reagent	Manuf. Lot # or CAS Chem ID	ml added	Inititials

Additional comments and/or explanation of all discrepancies noted above:

Client approval to run samples if discrepancies noted: Date: 5

SR # : J 0501960 Date: 5-12-05 Initials: DJS

Note that pH is checked and meets the required pH criterion listed in the column heading unless otherwise noted on cooler receipt form.

	Bottle Code																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	40mL	40mL	40mL	40mL	125mL	125mL	125mL	125mL	250mL	250mL	250mL	250mL	250mL	250mL	250mL	500mL	500mL	500mL	1L	1L	1L	1L	1L	2oz	4oz	8oz	16oz	5g	100mL	Misc.
Container	G	G	G	G	P	P	P	P	P	P	P	P	P	G	G	P	P	P	P	P	G	G	G	G	G	G	G	ENC	P	Misc.
Pres.		HCl	Sodium Thiosulfate	H2SO4		HCl	H2SO4	HNO3		H2SO4	HNO3	ZnAcetate NaOH	NaOH		HNO3		H2SO4	HNO3		HNO3		HCl	H2SO4						Sodium Thiosulfate	
Req. pH	N/A	<2	N/A	<2	N/A	<2	<2	<2	N/A	<2	<2	>9	>12	N/A	<2	N/A	<2	<2	N/A	<2	N/A	<2	<2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sample #	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-	-				-	-
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