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IMPLEMENTATION STUDY FOR PARTICLE SEPARATION

USMC SMALL ARMS FIRING RANGES, FORMER MARE ISLAND NAVAL SHIPYARD, CALIFORNIA

APRIL 27, 2004

Prepared for:
TETRA TECH FW, Inc.

Prepared by:
Brice Environmental Services Corporation

TETRA TECH FW, INC.

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5.0

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SUBJECT: IMPLEMENTATION STUDY FOR PARTICLE SEPARATION, MARINE CORPS FIRING RANGE, MARE ISLAND NAVAL SHIPYARD, VALLEJO, CALIFORNIA

Reference: Contract N68711-D-5713, Environmental Remedial Action Contract for Sites in Southern California, Arizona, New Mexico and Southern Nevada

Dear Mr. Rollefson,

Attached is the report of the implementation study for particle separation via wet processing as prepared by Brice Environmental Services Corporation. One purpose of the study was to investigate if the challenging high clay-containing site soils could be successfully "slurried" and processed via wet sieving and density separation to ensure efficient particulate lead removal. A second was to determine the actual field implementation approach and equipment needed for the process. TtFW has reviewed the results of the study and has concluded that, although a somewhat viable treatment on a bench-scale, the process of wet separation as a mechanism to reduce lead levels in contaminated soils would not constitute a favorable final treatment approach. It involves too many equipment application uncertainties to be executed with confidence in the field.

The study shows that particle separation will reduce the total lead concentrations in the soil. The majority of the particulate metal (bullet fragments) found was coarse in nature and larger than +10 mesh. The lab separation process was highly efficient showing a particulate lead reduction rate as high as 99 percent. However, post wet processing, the soil fractions still showed high concentrations of lead that were much above leach standards and the site Target Cleanup Goal (TCG).

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In the study, Brice Environmental employed a three-step process to separate solid lead fragments from soil. Composite soil samples were collected from four (4) locations throughout the firing range. These samples were intended to represent a "worst-case" scenario in terms of physical soil characteristics and/or lead contamination. The steps were:

1. Deagglomeration – Soil is deagglomerated into a slurry of discrete particles. Once the soils are deagglomerated, particles containing lead and vegetation can be isolated and recovered.

2. Particle Separation – For particulate contaminants similar in size to the surrounding soil, gravity separation is used to remove the contaminants.

3. Dewatering/Water Treatment – Process water used in previous steps is recycled and/or treated within the plant.

The most challenging step in this treatment process was seen to be deagglomeration. A 1-hour retention time was required using a mixer with 80 percent water by weight added to completely slurry the material. This produced marginal success on a lab scale. A full-scale field application would require "shake down" testing and field modifications are highly probable. This step involves high technical risk and high cost.

Particle separation was found to be effective in the lab. However, as mentioned above, post-wet processing, the soil fractions still showed high concentration of lead.

The last element, dewatering, is a challenging and complex step. Water used in previous steps was seen to become contaminated with lead rendering treatment necessary. Coagulants (aka flocculants) appeared effective, but they were also consumed in the process, rendering water treatment expensive to maintain. Additionally, it was felt that soil variability may cause extensive "shake down" trial and error and that field modifications are very probable.

In addition to the results from the above treatment processes applied, several other conclusions emerged from the tests. For example, it was concluded that the use of field portable X-ray fluorescence (XRF) equipment to analyze lead levels in soils did not show good correlation with the lab performed EPA Method (3050B/7420).

Examination of bullet fragments also revealed that the metal surfaces showed varying degrees of corrosion. It was concluded that fragments imbedded in clay clods showed virtually no corrosion at all, which would indicate that oxidation of the surface is minimal under those conditions and the possibility for metal contamination of the surrounding soils is significantly reduced.

In summary, although Brice found their treatment effective in the laboratory, TtFW does not recommend this for approach for field treatment of Mare Island Marine Corps Firing Range soils. As a field technology, this treatment is untested, risky and expensive. Please review the enclosed report and if you have any questions, please do not hesitate to contact us at (619) 471-3532 (Kent) or (619) 471-3528 (Ulrika).

Sincerely,

Kent Weingardt
Project Manager

Ulrika T. Messer
Project Engineer

Attachment:
IMPLEMENTATION STUDY FOR PARTICLE SEPARATION

Copy to:
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TETRA TECH FW, INC.

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EXECUTIVE SUMMARY

Management of heavy metal contaminated soil from Small Arms Firing Ranges (SAFR's) presents substantial economic costs and environmental challenges. Contamination exists initially as spent lead ammunition in and around the target berms. Over time, metallic lead exposed to the elements in surface soil will oxidize to an ionic and more soluble lead form. The corroded lead then dissolves in rainwater, contaminating soil grains and soil vegetation to depth in target berm soils. Fine particulate lead as well as dissolved lead and contaminated soil fines can also be transported to areas away from the target berms in surface water runoff. As a result, lead contamination at SAFR's can become wide-spread, existing both as discrete particles (bullets, bullet fragments and finer-sized heavy metal particles) and ionic (adsorbed) heavy metals on the soil grains.

Stabilization of heavy metal contaminated soils to mitigate leachability is a standard treatment approach for soils classified as Non-RCRA (22 CCR California) Hazardous and/or RCRA (40 CFR) Hazardous. Stabilization is effective at immobilizing lead ions but will not immobilize particulate lead. The corrosion of particulate lead left in "non-hazardous" stabilized soil over time, can render the soil hazardous.

Particle separation (particulate lead removal) removes the source of soil total lead contamination and to remove the threat of future leachability. The intent of this study was thus to evaluate particle separation for implementation at the USMC Small Arms Firing Ranges located at Former Mare Island Naval Shipyard, California. Soils collected for evaluation were from four locales, including: (1) Rifle Range Floor; (2) Rifle Range Impact Berm; (3) North Pistol Range Impact Berm; and, (4) the South Pistol Range Impact Berms stockpile. Soils evaluated were "worse-case" in terms of physical soil characteristics and/or lead contamination. The intent behind evaluating worse-case material was to ascertain the feasibility of processing the most difficult soils at the site to ensure that implementation would be successful.

Findings are summarized below:

1. This study confirms 1999 findings that particle separation will dramatically reduce total lead concentrations in soils where particulate metal is found. Removing particulate metal will eliminate the threat of particulate lead continually corroding over time and releasing lead into the soil. Long term corrosion and dissolved lead migration into the soil column will continue without particulate lead removal

2. A high production water-based particle separation process is technically feasible. There are numerous advantages to using this technology. Water-based particle separation:

- √ Is highly efficient at recovering particulate lead. Raw soil and post treatment soil total lead test results from both 1999 and 2004 indicate the lead reduction rate will be as high as 99 percent.
- √ Provides a closed system that remains unaffected by external conditions. The system permits control of the conditions under which the soil is treated.
- √ Allows hazardous soil to be excavated and treated on-site.
- √ Utilizes water, thus eliminates dust concerns
- √ Consists of unit components that can be configured in many different arrays to meet specific treatment requirements on a site-by-site basis.
- √ The technology can be used in conjunction with other treatment technologies for complete soil treatment such as stabilization, thermal desorption, or chemical treatment.
- √ Is an increasingly cost-effective treatment approach on a per-ton basis with increasing soil volumes.
- √ Overall: (1) is capable of day-in/day-out production at high throughput rates, (2) is transportable and can be brought directly to the jobsite, and (3) preconditions and creates a uniform material for subsequent treatment technologies, if required.

3. Particulate metal removal may be required to guard against future leachability of stabilized soils. There is a potential liability concern with disposing of soils containing particulate lead in a landfill.
4. Soil vegetation (fine roots, leaves, and straw) contains high lead concentrations, at levels exceeding 23,000 mg/kg. Removing this material from the soil reduces soil total lead concentrations.
5. Raw soils in locales of particulate lead deposition show elevated TCLP and STLC levels. Stabilization may be required for some soils at the site and can be performed as part of particle separation processing. Having particle separation and stabilization as one continuous process will make for a more cost effective and efficient operation. As such, information regarding stabilization product characteristics, required dosage rates, and costs should be integrated into the particle separation task for one turn-key treatment process.
6. Technical uncertainty was addressed through the use of analytical equipment, bench-scale particle separation equipment, and general soil processing equipment for modeling

and simulation. Two crucial areas of soil processing were identified as posing technical uncertainty at high production rates: (1) pulping the soil into slurry to facilitate downstream particulate lead removal, and (2) dewatering the soil. Uncertainty for these two steps was addressed by:

- √ In-depth modeling and system design engineering at the Brice facility by key staff who have been with the company since inception;
- √ Submitting sample material directly to the manufacturers of specialty pulping and dewatering equipment for independent second party determinations of requirements and production rates, and incorporating their finding and recommendations into the overall system design;
- √ Allowing an extended period of process "shake-down" in the field to slowly increase the production rate and make modifications to maintain efficiency;
- √ Costing the work to allow for modifications of unit components and/or insertion of additional components into the process train to ensure production and efficiency, and;
- √ Dedicating the highest level of experience for process set-up and shakedown. This includes Brice personnel that have overseen or been involved with every treatability study and field project to date, as well as second-party technical support and installation staff from the manufacturer of dewatering equipment selected for this project.

7. Implementation costs on a per-ton basis are a function of the soil quantity requiring treatment. For a minimum of 50,000 yards or 75,000 ton of material, pile-to-pile all-inclusive costs are estimated at $69 per ton. Higher per-ton costs are realized for quantities less than 50,000 yards. For a minimum of 20,000 yards or 30,000 tons of material, pile-to-pile all-inclusive costs are estimated at $120.60 per ton.

1.0 BACKGROUND

Brice and Battelle conducted extensive field sampling and laboratory process testing of soils from the site in January, 1999. Findings are contained in the May 28, 1999 document titled *"Treatability Study Report For Remediation of the Mare Island Present Day U.S. Marine Corps Small Arms Range Soils at the Former Mare Island Naval Shipyard, Vallejo, California.*

Composite samples were collected using an excavator, with sample depths driven by the presence of

particulate metal. The samples were then analyzed for complete total lead. The data presented in Table 1 below shows the raw soil total lead concentration separately as particulate lead, non-particulate residual soil total lead, and the total soil lead concentration from both lead sources. The last column shows the percentage total lead reduction using particle separation to remove particulate lead.

Table 1. Previous Findings

Sample/Location	Particulate Metal Lead Concentration (mg/kg)	Residual Soil Lead Concentration (mg/kg)	Total Soil Lead Concentration (mg/kg)	Lead Reduction (%)
Bucket #1 (Range 2 Impact Berm)	230,266	7,433	237,699	96.9
Bucket #2 (Range 5 Impact Berm)	159,824	2,059	161,883	98.7
Bucket #3 (Range 2 Impact Berm Backside)	14,902	231	15,133	98.5
Bucket #4 (Range 6 Impact Berm)	33,032	1,053	34,085	96.9
Bucket #5 (Range 9 Impact Berm)	24,387	933	25,320	96.3
Bucket #6 (Pistol Floor Composite)	8,612	130	8,742	98.5
Bucket #7 (Pistol Range Sideberm Composite)	8,957	67	9,024	99.3
Bucket #8 (Rifle Range Floor Composite)	5,683	60	5,743	99.0
Bucket #9 (Rifle Range Impact Berm Composite)	48,433	6,734	55,167	87.8
Bucket #10 (Rifle Range Sideberm Composite)	0	44	44	0

The results from 1999 showed the following:

1 Lead contamination is primarily particulate lead.

2 The data indicate the potential to grossly underestimate lead levels in soils because the majority of the lead occurs as large particulate metal. Conventional EPA test methods only focus on the residual soil lead and ignore lead that is particulate.

3 Lead reduction efficiency will be variable and a function of (1) the amount of particulate lead in the raw soil and (2) non-particulate residual soil total lead concentrations. Lead reduction efficiency will range from 0 percent for soils containing no particulate lead to as high as 99 percent for soils containing particulate lead and low residual soil lead concentrations.

4 Vegetation (leaves, sticks, grass, etc.) in the soil functions as a contaminant "sink" for lead. Lead concentrations of the material ranged from 200 mg/kg to over 18,000 mg/kg. Removing both particulate lead and vegetation is required to reduce soil total lead concentrations

5 Some soils following particulate lead removal will contain residual total lead concentrations less than 200 mg/kg.

6 Some soils following particulate lead removal will contain a residual total lead concentration (TTLC) greater than 200 mg/kg and less than 1,000 mg/kg (Nonhazardous Waste).

7 Some soils following particulate lead removal will contain a residual total lead concentration greater than 1,000 mg/kg total lead (Non-RCRA California Hazardous).

8 Some soils following particulate lead removal will be RCRA and/or Non-RCRA California hazardous for leachable lead.

1.1 Study Criteria

The 1999 study served as the basis for the current work, which was to determine particle separation process requirements for field implementation and to develop current cost information.

Performance criteria are summarized below:

1) Determine the requirements for particulate lead removal with a durable, robust process for consistent and continuous day-in and day-out production

2) Recover metal with a purity suitable for recycling

3) Use no environmentally hazardous material

4) Contain and recycle all process water with no settling ponds

5) Produce density treated soils that are stackable to facilitate disposition

1.2 Field Sampling

The project scope of work was two-fold. First, soils from the site were evaluated to derive soil and lead characteristics and then subjected to physical treatment testing to derive field process parameters for recovering particle lead and vegetation. Table 2 below details the sampling strategy for the study. "Worse-case" soils were generally collected for evaluation to ensure field process success. Second, a field process was designed incorporating soil information for implementation at the site.

Table 2. Sampling Strategy

SAMPLE	LOCATION	RATIONALE
1	South Pistol Range Impact Berms – Stockpile #2 Sample area: 1-1, 2-2, 2-5, 3-2, 3-3 or 5-2 (refer to stakes marking prior sample locations on stockpile)	Stockpile/composite: High clay content and high particulate metal concentrations – composite represents "worst-case" in terms of soil characteristics and particulate metal loading and "best-case" in terms of particulate metal recovery.
2	Rifle Range Berm – Sample area: POL-DD-Upper Depth: 12"-18"	High risk area: Confirmed high (consistent) lead above TCG, high clay content. "Worst-case" material in terms of fragmented fine particulate metal.
3	Rifle Range Floor – Sample area: Between (FF) GG, HH-5 to (FF) GG, HH-17. AVOID firing stand area because of their green sand content.	High risk area: The soil represents the volume of what we are expecting to have to process. Rounds expected to be more fragmented than pistol rounds so sample provides "worst-case" data on

	Depth: 12"-18"	particulate metal quantity/distribution where splattering and fragmentation has occurred.
4	North Pistol Range Berm – Sample area: POL-Q-Upper / POL-P-Upper Depth: 0"-6":	High risk area: Confirmed hot spot above TCG. Bullets less shattered/fragmented.

Representatives from Tetra Tech and Brice collected the following soil quantities for testing at Brice's Fairbanks lab:

1. South Pistol Range Impact Berms (Stockpile #2) – 149 lbs
2. Rifle Range Berm – 34 lbs
3. Rifle Range Floor – 39 lbs
4. North Pistol Range Berm – 51 lbs

2.0 STUDY APPROACH

2.1 Study Objectives

The primary objective of the study was to determine the implementation requirements and estimated costs of employing particle separation for recovering particulate lead and lead contaminated soil vegetation.

2.2 Study Design

Specifics regarding the study design are discussed below:

1) For the study, samples consisted of soil collected from the various sites listed in Sec. 1.2.

2) Physical studies were initiated to determine the characteristics of the soil with respect to soil gradation, particulate lead and vegetation distribution. Physical treatment was imposed on the soil mass as if the soil were processed with an actual plant. The trials simulated the density treatment processes typically used for recovering particulate lead as well as soil vegetation. Previous studies have shown that soil vegetation can be a major contaminant "sink" and as such, the study featured a vegetation removal step.

3) Select treated soil fractions were advanced for analysis of total lead. The analytical results revealed information regarding the viability of the technology to treat the complete soil mass, or a significant portion of the soil.

3.0 STUDY PROCEDURES

Procedures used in this study can be categorized into five components: (i) Soil Characterization and Particle Separation; (ii) Soil Management; (iii) Data Management; (iv) Secondary Product Management; and (v) Quality Assurance/Quality Control.

3.1 Soil Characterization and Particle Separation

Tetra Tech shipped the 5-gallon buckets to Brice's Fairbanks Alaska laboratory. The buckets arrived in Fairbanks in good condition with the lids intact and no container breakage was noted.

Procedures included the following:

1) Initially weighing each as-received bucket to determine soil quantity.

2) Checking the soil visually for any unanticipated contamination. Assessing the soil for particulate metal, soil moisture, and pH.

3) Soil Characterization

    a. Wet-sieving the soil from each site using #10 mesh (.079 inches or 2.00 millimeters, #20 mesh (.033 inches or .84 millimeters), 50-mesh (.012 inches or 0.297 millimeters), 100-mesh (.006 inches or 0.149 millimeters), and 200-mesh (.003 inches or 0.074 millimeters) screens for a gradation determination.

    b. Subjecting the material retained on each of the above screens to density treatment for separation and recovery of particulate metal and vegetation consisting of leaves, sticks, fine grass and other decomposing vegetative debris. Drying and weighing the material for inclusion in the soil particle distribution calculations.

    c. Placing all plus #200 mesh soil and density recovered fractions in a drying oven for subsequent weighing to determine the fractional soil percentage contributions.

    d. Storing the minus #200-mesh soil slurry remaining from the wet sieving trials to test flocculants for field implementation of fines recovery. Utilize a stock solution made using a suitable quantity of various types and brands of chemical. Determine a dosage rate for forecasting coagulant requirements at field scale.

    e. Placing the tested coagulated minus #200 mesh soil fraction into a stainless steel pan and into the drying.

    f. After drying, removing all soil fractions and non-soil constituents from the dryer and after temperature adjustment, weighing each soil fraction and non-soil constituents for determining fractional contributions (soil gradation).

g. Once all weights were recorded determining the fractional percentages for characterizing the soil.

h. Total lead testing of the physically treated soil via X-ray fluorescence and EPA Methods

4) Physical Treatment Trials.

a. Applying physical treatment to determine requirements for particle separation.

b. Evaluating the results.

5) Reviewing analytical and treatment trial results. Incorporating findings into designing a field process for implementation.

3.2 Soil Management

Soil samples were handled with stainless steel sampling spoons. All laboratory equipment was decontaminated prior to use in the study. All excess soil was maintained as sized fractions for recomposition for shipment and stabilization testing.

3.3 Data Management

All laboratory data was recorded in a bound notebook. All project-related information was placed in the project folder along with any computer disks, records of correspondence, etc.

3.4 Secondary Product Management

All solids and liquids used in the study were managed in a controlled fashion. Excess soil from the study was returned to its respective 5-gallon bucket. Water used for the study was placed into large stainless-steel tubs and placed into a drying oven and evaporated. The tubs were then rinsed with soap and water and scrubbed to remove any surficial coatings followed by rinsing with purified water. The small amount of wash water and solids from the evaporation step, along with all other solids generated by the study were returned to the 5-gallon soil buckets. The buckets will be properly disposed of upon completion of the study.

3.5 Quality Assurance/Quality Control

All sample handling, testing, data acquisition, and data reduction followed standard quality assurance/quality control (QA/QC) protocols, guided by standard good laboratory practices. Brice maintains electronic files and hard copy records of procedures, raw, and reduced data for all studies performed on soils from throughout the country, as well as a Laboratory Quality Assurance/Quality Control Plan, Laboratory Health and Safety Plan, and MSDS's.

4.0 SOIL CHARACTERIZATION

Soil parameters such as moisture, gradation, distribution of particulate metal and vegetation were

determined for designing the field process. Soils were deagglomerated and density treated for vegetation and particulate metal removal, followed by dewatering. Individual soil fractions and non-mineral soil constituents from density treatment were subsequently dried and weighed. Total lead concentrations were determined for all constituents to derive the lead distribution within the soil matrix. Raw soil feed total lead concentrations were calculated from the fractional percentages and total lead concentrations. Reductions in soil total lead from density treatment were also calculated as well as soil leachability.

4.1 Soil Inspection

The soil samples from the site were inspected for the presence of any unusual items. Soils consisted of wet plastic clay, as expected since samples were intentionally selected from locales determined to be "worse-case" in terms of soil characteristics.

Several samples contained obvious pieces of bullets and bullet fragments, again as expected as samples were also selected from locales determined to be "worse-case" in terms of lead contamination. Some clay clods when broken apart were found to contain bullets and bullet fragments. Bullets and bullet fragments showed varying degrees of corrosion. Those found embedded in clay clods were generally very clean to the point of appearing to having been only recently fired. Other bullets and bullet fragments not embedded in a clay matrix were highly corroded. With copper jacketed rounds, the lead component will preferentially leach because it is more easily oxidized.

4.2 Soil Moisture

A subsample from each locale was weighed and dried for a moisture determination. Soil liquid limits and plasticity vary depending on the percentage of plastic clay in the matrix. When the plasticity index (PI) is high, soils have a high liquid limit (LL). Previous results showed soils at the site to have a range of PI/LL's from 41 percent/77 percent, to 24 percent/43 percent respectively.

The as-received soil moisture contents for the soils were as follows:

1) South Pistol Range Impact Berms Stockpile – 13.8%

2) Rifle Range Berm – 23.2%

3) Rifle Range Floor – 22.0%

4) North Pistol Range Berm – 14.4%

The soil moisture for the South Pistol Range Impact Berms Stockpile soil was low because soils had been excavated and placed under a tarp. The Rifle Range samples contained the highest moisture contents because they were taken from 12 to 18 inches below grade, whereas the North Pistol Range Berm sample was taken from the surface to 6-inches below grade.

4.3 Soil pH

Soil pH levels were generally near neutral as noted below.

1) South Pistol Range Impact Berms Stockpile – 8.02

2) Rifle Range Berm – 8.45

3) Rifle Range Floor – 7.95

4) North Pistol Range Berm – 8.12

4.4 Fractional Distribution

Tables 3 through 6 present the raw data for soil gradation, particulate metal and soil vegetation. The tables contain the following information:

1 Material Distribution of soil, vegetation and particulate metal for each sample are shown as both gram weights and as a percentage.

2 Fractional Total Lead Results in the second set of data show total lead concentrations by grain size for the soil, vegetation, and particulate metal.

3 Fractional Total Lead Contributions show the contribution of total lead to the overall soil from each soil fraction as well as from vegetation and particulate metal.

4 Overall Raw Soil Total Lead

Table 3. South Pistol Impact Berms

MATERIAL DISTRIBUTION (Grams)				MATERIAL DISTRIBUTION (Percent)		
Particle Size (Mesh)	**Soil (gr.)**	**Vegetation (gr.)**	**Particulate Metal (gr.)**	**Soil (%)**	**Vegetation (%)**	**Particulate Metal (%)**
+10	2,692	-	55	22.9%	-	0.5%
+20	101	-	18	0.9%	-	0.2%
+50	246	-	4*	2.1%	-	(0.03)
+100	546	-	3*	4.7%	-	(0.03)
+200	100	-	-	0.9%	-	-
-200	7,952	-	-	67.8%	-	-
Totals	11,637	-	80	99.30%	0.00%	0.70%

FRACTIONAL TOTAL LEAD RESULTS

Particle Size (Mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)
+10	4,293	-	800,000	983	-	4,000
+20	9,497	-	500,000	85	-	1,000
+50	8,158	-	300,000*	171	-	90
+100	9,128	-	150,000*	429	-	45
+200	5,333	-	-	48	-	-
-200	1,558	-	-	1,056	-	-
Soil Total lead						**7,907**

Note: "-" denotes no material

* Metal is present but contribution is less than 0.1% of overall material. Lead contribution factored into overall soil lead concentration but not included in material distribution percentage.

Table 4. Rifle Range Impact Berm

MATERIAL DISTRIBUTION (Grams) MATERIAL DISTRIBUTION (Percent)

Particle Size (Mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)
+10	30.0	-	55.0	0.5%	-	0.9%
+20	51.0	6.0	-	0.8%	0.1%	-
+50	71.0	19.0	-	1.1%	0.3%	-
+100	71.0	-	-	1.1%	-	-
+200	105.0	-	-	1.6%	-	-
-200	6,039.0	-	-	93.6%	-	-
Totals	6,367	25	55	98.7%	0.4%	0.9%

FRACTIONAL TOTAL LEAD RESULTS

Particle Size (Mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)
+10	14,000	-	700,000	70	-	6,300
+20	13,990	24,000	-	112	24	-
+50	12,642	23,847	-	139	72	-
+100	10,870	-	-	120	-	-
+200	8,025	-	-	128	-	-
-200	4,733	-	-	4,430	-	-
Total Soil Lead						**11,395**

Table 5. Rifle Range Floor

MATERIAL DISTRIBUTION (Grams) MATERIAL DISTRIBUTION (Percent)

Particle Size (mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)
+10	173	-	-	2.4%	-	-
+20	126	-	-	1.7%	-	-
+50	362	-	-	5.0%	-	-
+100	262	-	-	3.6%	-	-
+200	390	-	-	5.3%	-	-
-200	5,981	-	-	82.0%	-	-
Totals	7,294			100.0%		

FRACTIONAL TOTAL LEAD RESULTS

Particle Size (mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)
+10	100	-	-	2	-	-
+20	100	-	-	2	-	-
+50	175	-	-	9	-	-
+100	106	-	-	4	-	-
+200	100	-	-	5	-	-
-200	133	-	-	109	-	-
Soil Total Lead						**131**

Table 6. North Pistol Range Impact Berm

MATERIAL DISTRIBUTION (Grams) MATERIAL DISTRIBUTON (Percent)

Particle Size (Mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)
+10	59	-	4,429	0.4%	-	32.2%
+20	10	14	27	0.1%	0.1%	0.2%
+50	22	26	8	0.2%	0.2%	0.1%
+100	79	60	2*	0.6%	0.4%	(.01%)
+200	302	-	-	2.2%	-	-
-200	8,689	-	-	63.3%	-	-
Totals	9,161	100	4,466	66.8%	0.7%	32.5%

FRACTIONAL TOTAL LEAD RESULTS

Particle Size (Mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)
+10	-	-	800,000	-	-	257,600
+20	2,160	15,080	700,000	2	15	1,400
+50	4,710	18,980	123,500	9	38	124
+100	4,419	20,880	75,000*	27	84	7.5
+200	25,000	-	-	550	-	-
-200	15,427	-	-	9,765	-	-
Total Soil Lead						**269,622**

* Metal is present but contribution is less than .01% of overall material. Lead contribution factored into overall soil lead concentration but not included in material distribution

4.5 Metal Composition

Recovered plus #10 mesh particulate metal from the South Pistol Impact Berms, Rifle Range Impact Berm, and North Pistol Range Impact Berm samples were recombined for a determination of lead content using a pyrometallurgical process. The pyrometallurgical method overcomes three shortcomings of the conventional acidic extraction method to prepare environmental samples for metals analysis, which are: (1) limited sample size with the extraction method; (2) saturation of the extraction fluid, and; (3) inability to dissolve metal lumps with the extraction fluid.

The pyrometallurgical method involves taking a sample of the recovered particulate metal and blending it with sufficient flux to maintain a reducing environment and to produce a stable slag that minimizes metal volatilization. The mix is then placed into a crucible and heated to 1,800 °F until melting is complete. Upon cooling, the slag is chipped away from the metal ingot and combined to form one slag sample. The ingot is sampled by drilling followed by digestion and analyses of the drill cuttings. Both the ingot and slag are analyzed for lead and the results from each product are combined to generate the percentage of lead in the metal sample. The metal percentage is converted to mg/kg and added to the mg/kg non-particulate lead results for the vegetation, soil, and water to derive accurate feed soil metal concentrations.

The metal composition was as follows:

- Lead % = 85.2
- Copper % = 11.6
- Antimony % = 0.9
- Zinc % = 2.2

4.6 Raw Soil Lead Leachability

A representative aliquot from each raw soil sample was subject to leachability testing. Both Toxicity Characteristic Leaching Procedure (TCLP) and Waste Extraction Test (WET) testing was performed, with the results shown below in Table 7. For the Rifle Range Berm and Rifle Range Floor duplicates were run as shown below.

Table 7. Leachable Lead Results

Leach Procedure	South Pistol Range Impact Berms (mg/L)	Rifle Range Berm (mg/L)	Rifle Range Floor (mg/L)	North Pistol Range Berm (mg/L)
TCLP	30	27/27	2.0/1.9	253
STLC	193	282/150	3.3/1.9	1,220

4.7 X-Ray Fluorescence

Field analysis is less expensive per sample than laboratory analysis because of less need for sample handling, transportation, and chain-of-custody documentation. In addition, the rapid analytical turn-around of a field method can provide timely support for field decision-making, and greatly reduce overall project costs. XRF testing of soils was evaluated to determine its accuracy compared to standard EPA methods for possible use in the field to (1) delineate soil boundaries during excavation and (2) to test soils during the course of treatment operations.

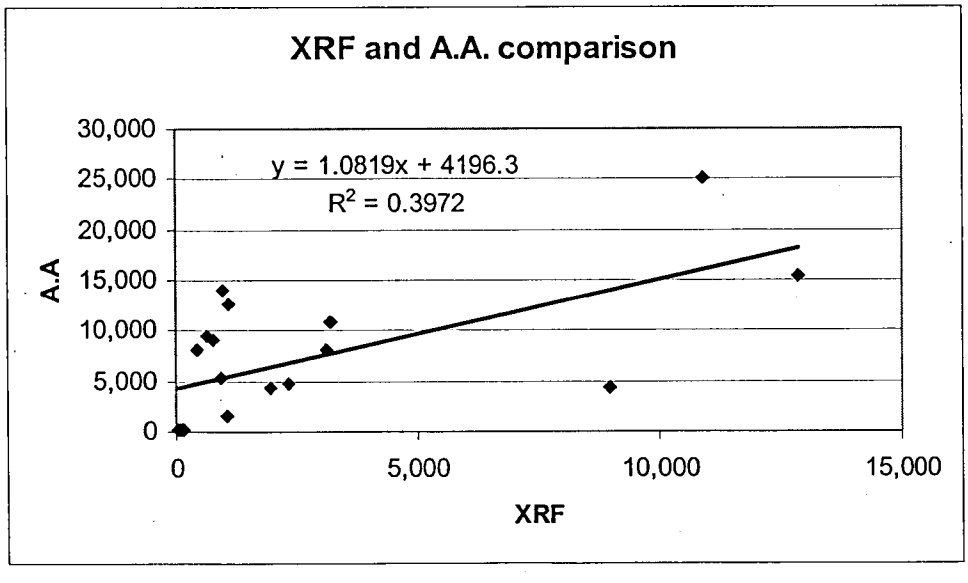
XRF works by exposing a sample to high-energy x-rays that eject orbital electrons, which causes metal atoms to emit a characteristic x-ray fluorescence spectrum of specific energy x-rays. This x-ray spectrum is filtered and analyzed to determine the quantity of metals in a sample.

Field portable x-ray fluorescence (XRF) continues to gain acceptance as a complement to traditional laboratory testing of metal contaminated soil. The quality of data produced by field XRF varies with site conditions, soil composition, and sample preparation. Quality assurance protocols for its use in the field usually stipulate that a number of field samples be split and sent to a laboratory for confirmatory analysis. This confirmatory analysis can provide valuable information of the effectiveness of the field methodology.

For the study, density-treated samples were used to compare XRF derived lead results with EPA Method 3050-6010 total lead results. Samples following density treatment were first analyzed via XRF, then subsequently digested and analyzed per the EPA Method.

The correlation coefficient between XRF data versus EPA Method data was poor as shown below in Figure 1. The data showed a correlation coefficient of 0.3972, with 1.00 a perfect fit. Although the comparison of data did not generate a good mathematical correlation, the results did reflect high lead soils where EPA Method testing indicated them to be high, and low lead soils where EPA Method testing indicated them to be low.

Figure 1. XRF vs. EPA Method Results



5.0 Engineering Evaluation

Laboratory equipment was used to model the physical treatment processes. Following is a description of the major process steps along with test findings.

5.1 Deagglomeration

For particle separation to be effective, soils must be deagglomerated into a slurry of discrete particles of clay, silt, sand, and coarser material. Once the material is deagglomerated then particle size band widths containing particulate lead and vegetation can be isolated and recovered from the soil.

Various unit components exist for deagglomerating soil. The simplest unit is the wet screen, which offers a short retention time and relies on water and vibration to break down material. A trommel is a long tube equipped with a scroll and lifer bars. Material is added at one end and scrolled forward in water to a screen. While offering a longer retention time than a wet-screen, a trommel relies on water and material tumbling to break down the matrix. Pug mills are more aggressive units that rely not only on water and retention time but also applied energy in the form of motor-driven paddles to abrade and cut the material. At the extreme end of deagglomeration units are blade mills, sol-clay washers, and log washers. These units rely on massively constructed and reinforced tubs with log shafts equipped with numerous overlapping paddles along with high horsepower and gear reducers to retain material and apply extreme energy for deagglomeration over time.

To model deagglomeration in the lab, material was initially subjected to washing on a lab scale vibratory screen (simulating wet-screening). Material was then advanced to a small cement mixer equipped with lifter bars where the material was tumbled and water added. The water-solids ratio and time required to break down the material was noted (simulating trommeling). Pending the outcome, material was then advanced to a large tumbler equipped with lifter bars and steel shot to determine the affects of retention time, water, and applied force in breaking down the material (simulating pug mills, blade mills, sol-clay washers and log washers). Site soils proved exceptionally tough to deagglomerate, thus a second sample was shipped directly to a manufacturer of specialty deagglomeration equipment for examination at their facility. This way, both Brice's and the manufacturers experience with similar material and application were utilized to derive the appropriate piece of equipment for most efficiently accomplishing the task.

Findings

Test results indicate that retention time, water and applied energy are crucial requirements for completely breaking down the soil matrix. Rendering the clay into slurry is required for particle separation to be effective. Results are as follows:

1 A 1-hour retention time was required using a mixer with 80 percent water by weight added to

completely slurry the material. Thus a long retention time and a considerable amount of water are required to slurry the material using passive agitation.

2 Wet-screening is ineffective as well as a trommel due to the long retention time requirements using passive agitation. With a trommel, complete breakdown of the material would not be expected due to the tendency of the material to roll into clay balls.

3 Water and a high degree of applied energy (horsepower, gear reducers, and paddles) will significantly reduce the time required to completely slurry the material. A log washer designed for a production rate of 225 tons per hour, but utilized at 40 to 50 tons per hour offers both the force and retention time required to ensure complete break down of the material.

4 Some soils at the site have been stockpiled and covered. When these soils are allowed to dry the material becomes extremely hard. Thus processing is compounded by having to re-wet dried soil and then slurry the material. Adding a pug mill ahead of the log washer to pre-condition soils for subsequent pulping will likely be required for dried soils.

5 Adding a rock recirculation system (1-inch to 3-inch rock aggregate) to the log washer will further accelerate the break-down of material. The addition of rock will accelerate deagglomeration and help facilitate high production rates. Adding rock in conjunction with the force applied with the log washer represents the maximum abrasion and force that can be applied to the material.

5.2 Particle Separation

When particulate contaminants are the same size as the surrounding soil particles, gravity separation/density treatment is used to remove the particulates from the same-sized soil matrix. Mare Island soil has a specific gravity of around 2.65. The particulate contaminants, which are lighter and/or heavier than the same-sized soil particles, are separated using mining-based density separation techniques of elutriation and jigging. In the lab, this was simulated using upward water flow in elutriation columns, a small water-pulsed mineral jig, and panning with gold pans.

Findings

Test results indicate the following:

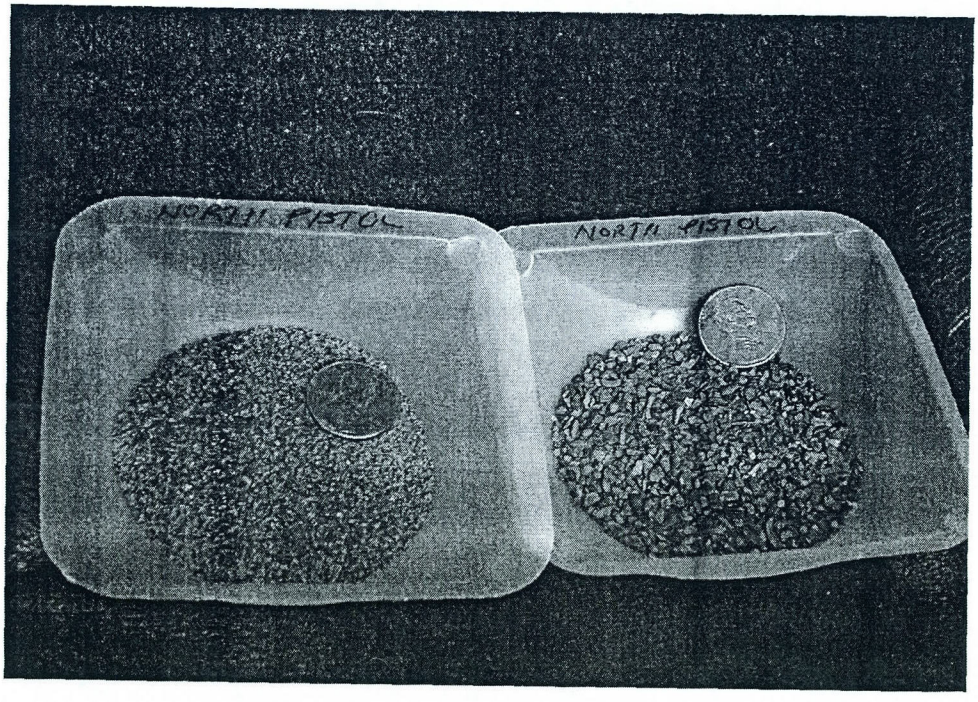
1 Mineral jigging will recover a refined lead product suitable for recycling. The photographs below show refined (1) plus #4 mesh metal and (2) minus #10 by plus #100 mesh metal and minus #4 by plus #10 mesh metal. Recovery efficiency is very high, well over 95 percent.

2 The vast majority of particulate metal is coarse in nature. Mineral jigging will generate a concentrate with a high metal purity.

2 Some fine particulate metal is present in site soils. It is suspected that fine metal will be limited to the top foot of the more heavily used impact berms only. Fine metal can be recovered using either fine material jigging, or specialty cyclones designed for the mining industry

Photograph #1. Refined Plus #4 Mesh Metal

Photograph #2. Refined Fine Metal



Density treatment will generate concentrates with high purities because (1) most of the soil contains large fragments or intact bullets, and (2) materials from most of the areas to be processed contain only minor amounts of soil with a similar particle size.

5.3 Dewatering/Water Treatment

To close the loop on water consumption, process water is recycled within the plant. A clarifier and continuous belt press (or centrifuge) in conjunction with coagulants are used in series in the field to dewater/condition the fines-slurry, and enable the reuse of process waters. Brice has found a coagulant (also known as a flocculant) that is a high molecular weight, water-soluble polymer known as a polyacrylamide to be very effective. This family of coagulants has a low environmental and human hazard and many are approved for potable water treatment.

For the lab study, coagulants were used to settle the fines from the wash water, and confirm dosage/effectiveness for subsequent field implementation. Coagulated fines were then subjected to filtering and dewatering to simulate belt press dewatering or high-speed centrifuging.

For this project, soils are exceptionally high in clay, thus a second sample was shipped directly to a firm specializing in fines dewatering equipment for examination at their own facility. As such, both firm's experience with similar material and application were utilized to derive the appropriate soil dewatering system equipment layout for most efficiently accomplishing the task.

Findings

Results indicate the following:

1. Soils consist of a very high percentage of fines, hence design must consider that virtually all of the feed soil will consist of soil fines that must be dewatered.

2. First-stage clarification and coagulation is most effective when the solids percentage in water is around 7 to 10 percent. At a higher fines percentage additional coagulant is required to "glue" fines together. This results in excessive coagulant costs.

3. Soil fines can be coagulated to form a durable floc that will not break down under belt pressing or centrifuging. Belt pressing will be successful for dewatering soil fines. Two 3-meter belt presses will provide the capacity for feed soil rates of 40 tons per hour. Second stage flocculation for final dewatering and solids recovery using belt presses appears feasible with a solids content of 25 percent.

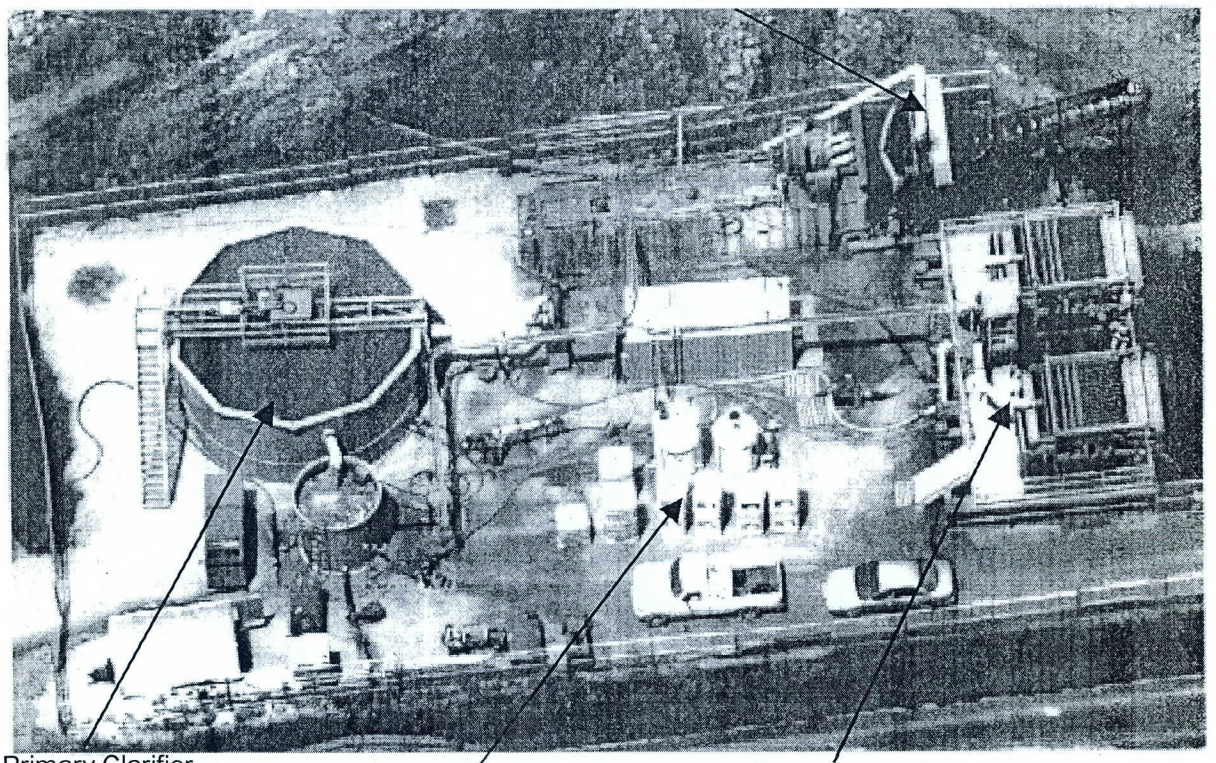
4. The liquid limit (LL) is defined as the water content in percent at the plastic-liquid boundary. Plasticity index (PI) is a value derived from the difference between the liquid and plastic limits and is the range of water contents over which a soil is plastic. Soil liquid limits are high and soils are highly plastic. As such, soil fines will retain a high percentage of water

without releasing free liquid. Dewatered soil fines from belt pressing will likely contain a moisture content in the 60 percent range.

5 Wet feed soils will result in less make-up water then dry soils. How wet or how dry feed soils will average is speculative, but a 30 percent moisture content spread between soils going in (30%) and soils going out (60%) will require approximately 117 gallons of makeup water per minute at 40 TPH and 100 percent fines. Allowing soils to dry out under tarps not only renders soil rock-hard, but also results in excessive plant water demands. *Soils destined for processing should not be covered with tarps and allowed to dry out.* This makes the material both more difficult to slurry and results in higher plant make-up water demands.

Photograph #3 shows a fines dewatering process similar to that required for this project involving a clarification step, slurry thickening step, and dewatering step using belt presses.

Photograph #3. Similar Fines Dewatering Process



5.4 Process Water

Approximately 20 pounds of North Pistol Range soil was added to 4 gallons of water and allowed to

sit for 10 days. This soil was selected because results showed it to be "worse-case" in terms of lead contamination. The water was then tested for dissolved lead. The dissolved lead level was 2 ppm.

Findings

1) All process water can be recirculated and no settling ponds are required. Make-up water requirements will be the difference between the moisture content of the feed soil and moisture content of the dewatered soil exiting the plant.

2) Some lead will dissolve into solution. A sand filter and activated carbon unit will be required to remove dissolved lead from solution and to prevent lead build-up in the recirculating process water.

6.0 QUALITY ASSURANCE/QUALITY CONTROL EVALUATION

The performance of soil preparation equipment, analytical instruments and all other devices used for tests conducted in the treatment study were satisfactory, with no problems adversely affecting the overall precision or accuracy of measurements. No instrument or equipment problems occurred during the course of the study.

7.0 FINDINGS AND CONCLUSIONS

Various sites at Mare Island were sampled and evaluated to determine the viability of employing particle separation for reducing total lead concentrations in the soil.

Results indicate the following:

1. Samples collected for testing represented "worse-case" soils in terms of lead concentrations. Finding from this study in conjunction with 1999 findings indicate that particle separation will dramatically reduce total lead concentrations in soils where particulate metal is found.

2. Removing particulate metal will eliminate the threat of particulate lead continually corroding over time and releasing lead into the soil. Long term corrosion and dissolved lead migration into the soil column will continue without particulate lead removal.

3. Removing particulate lead prior to stabilization is mandatory. Metal removal is required to guard against future leachability of already stabilized soils.

4. Soil samples collected for testing represented "worse-case" soils in terms of soil characteristics. Turning the clay soil into slurry is mandatory to facilitate downstream particle separation. Once the clay is pulped however, particulate metal removal is straightforward. Soil characteristics mandate a highly specialized and site-specific process to: (1) slurry the material in order to

facilitate particle separation, and (2) to dewater the material for discharge and disposition. Per-ton treatment costs will thus be higher than usual.

5. Turning the clay soil into slurry is also mandatory to facilitate downstream removal of highly contaminated soil vegetation. Once the clay is pulped, vegetation removal is straightforward.

6. Process water testing show the tendency of lead to dissolve in water at low levels. Process water will require treatment during soil processing and prior to discharge upon project completion. Brice has a sand filter/activated carbon treatment system to remove dissolved metals and can process the plant water upon project completion prior to discharge.

7. Raw soils in locales of particulate lead deposition show elevated TCLP and STLC levels above regulatory standards. Stabilization may be required for some soils at the site and can be performed during particle separation processing. Combining particle separation and stabilization as one continuous process will make for a more cost effective and efficient operation. As such, information regarding stabilization products, dosage rates, and costs should be integrated into the particle separation process design and costs as one complete treatment process.

8.0 IMPLEMENTATION

Results show that wet particle separation can effectively be used to remove particulate lead from site soils. Factors to consider in the implementation of this technology include:

Scale. Various factors directly or indirectly influence the scale of the operation. Issues such as allowable hours of operation and operating days per week both at the facility and out in the field affect plant scale. The soil production rate should be such that the process rate, the rate at which soil can be brought in from the field, and also the rate that processed soil and products can be removed from the facility are complimentary.

Soil Management Pad. A relatively large (400 ft x 400 ft, or larger) asphalt or concrete treatment pad and containment area would be required for operation of the equipment and management of the soil and products destined for recycling. Numerous open areas and parking areas exist at Mare Island and could be utilized for this purpose. Operations should be conducted on a pad equipped with a berm around the perimeter to contain soils and water. Ultimately, pad size needs to consider footprint requirements for raw soil and processed soil waiting testing and/or disposition. Slow analytical turnaround times for processed soil results in larger pad requirements. A factor that must be considered with a pad is rain water management.

Logistics. The full-scale plant will process hundreds of tons of soil per day. As such, excavation, and transport will have to be planned in close concert with processing activities. Treated soil testing and

removal will require the same close attention to prevent gridlock and down time. This will require careful management of the total scope of work to facilitate integration of the various features of the work for an effective operation.

Onsite Sample Preparation. Mining-based sampling and sample preparation procedures reduce bias and should be used for full-scale treatment operations.

8.1 Process Description

Brice Environmental has learned many lessons from previous field and treatability study projects. These lessons have allowed us to develop the process for implementation at Mare Island. Important lessons learned from previous work include the following:

- √ In-situ soil samples collected for a treatability study can vary with respect to gradation, metal concentration, and distribution compared to the final excavated and stockpiled soil.
- √ The results of the treatability study must be viewed as the "best case" and they should be extrapolated conservatively when up scaling to a field-scale process. Lab results are obtained under ideal conditions and cannot be transferred, in whole, to the handling, processing and efficiency of the field equipment.
- √ The field plant must incorporate non-complex treatment and processing componentry to minimize downtime and personnel requirements. Simple equipment is also most amenable to rapid modification
- √ The project must be staffed with personnel that not only have technical backgrounds, but have hands-on "wrench-turning" experience in the field.
- √ Previous recycling experience, regulatory familiarity, and a relationship with the smelting industry is essential to identify and resolve potential problems and delays associated with metal recycling.
- √ Small-arms range fieldwork has high visibility, thus it is essential that a clean operation be maintained at all times, quality equipment be used, plant leaks be addressed, and a stackable soil product be generated.
- √ Downtime is detrimental to the project schedule and to future considerations for implementing the technology at other sites.

The conceptual particle separation processes is illustrated below, showing major plant components. Some equipment changes may be made as the field approach is finalized. A general equipment descriptive is below.

1. Feeder

(4) Screw live bottom 5' x 8' x 11'.

(4) 7.5hp 1,750 RPM 460V severe duty motors.

(1) 5'-8" x 9' x 8' tall hopper for live bottom

2. Feed Conveyor

(1) 24" x 40' variable speed conveyor.

(1) 5 hp TEFC motor.

(1) Milltronic or Accumass electronic belt scale with push button programming, backlit display, zero and span test weight calibration routines. Speed sensor pulley.

3. Pug Mill

(1) 8' x 20' twin shaft pugmill.

(2) 40-hp motors.

Walkway with railings and ladder.

4. Logwasher

(1) 38' x 9' logwasher with twin shafts and 113 paddles per shaft and 3/8" plate steel tub construction. (1) 200-hp v-belt drive arrangement and 28 rpm shaft rotation.

(2) 24" x 24" clean-out ports on bottom of tank. Empty load = 53,000 lbs, live load = 95,500 lbs.

(1) Slurry pump wth 40-hp motor, open faced impellor with slurry box.

5. Coarse Material Conveyor

(1) 24" x 40' variable speed conveyor. (1) 5 hp TEFC motor.

6. Density Treatment Skid

(2) 48-inch coarse metal circular jigs. (2) 3 hp TEFC motors. (2) 10-mesh jig screens. (1) stand with ladder, walkways, and railings. (1) Fine metal circular jig with draw off cup and pinch control valve. (1) 1 hp TEFC motor.

(1) Metal dewatering screen. (1) 5-hp motor and pump for bullet vacuum system.

(1) Stand and rack for holding supersacks to contain metal. (1) Sandscrew – 22" single screw, 7.5 hp TEFC motor. (1) 20-hp Sala open faced slurry pump (1) Coarse Vegetation Removal Screen.

7. Fine Metal Compound Cyclone

(1) Cyclone will be used for the slurry exiting the log washer to recover any incidental fine metal entrained with the material.

8. Density Tank

(1) 9,000 gallon tank with agitator. (2) 4" pneumatic KGV for belt press feed pumps.

(1) sonic level sensor.

9. Belt Presses

(2) 3-meter, 6-pressure roll, skid mounted, all pneumatic presses.

(1) density gauge, (2) float meters, (2) static mixers,

(2) flocculators, (1) pressure relief valve for dilution water (1) dilution water control valve,

(1) basket strainer for belt press spray water,

(1) air compressor.

10. Coagulant Skid

(1) 80 GPM floc make-up system,

(2) 16 gpm belt press floc pumps,

(1) 8 gpm clarifier floc pump,

(3) 2,500 gallon chemical storage tanks,

(1) 150 gpm transfer pumps,

(2) 2.5 hp blowers, (2) 5 gph belt press pumps

11. Circular Clarifier

(1) 2,100 gpm feed, 3-piece field boltable 30' diameter with steel floor, 10' side wall,

(1) mud level sensor and valves.

12. Clean Water Storage Tank

(1) 500 bbl 8' x 8' x 10' metal tank, towable.

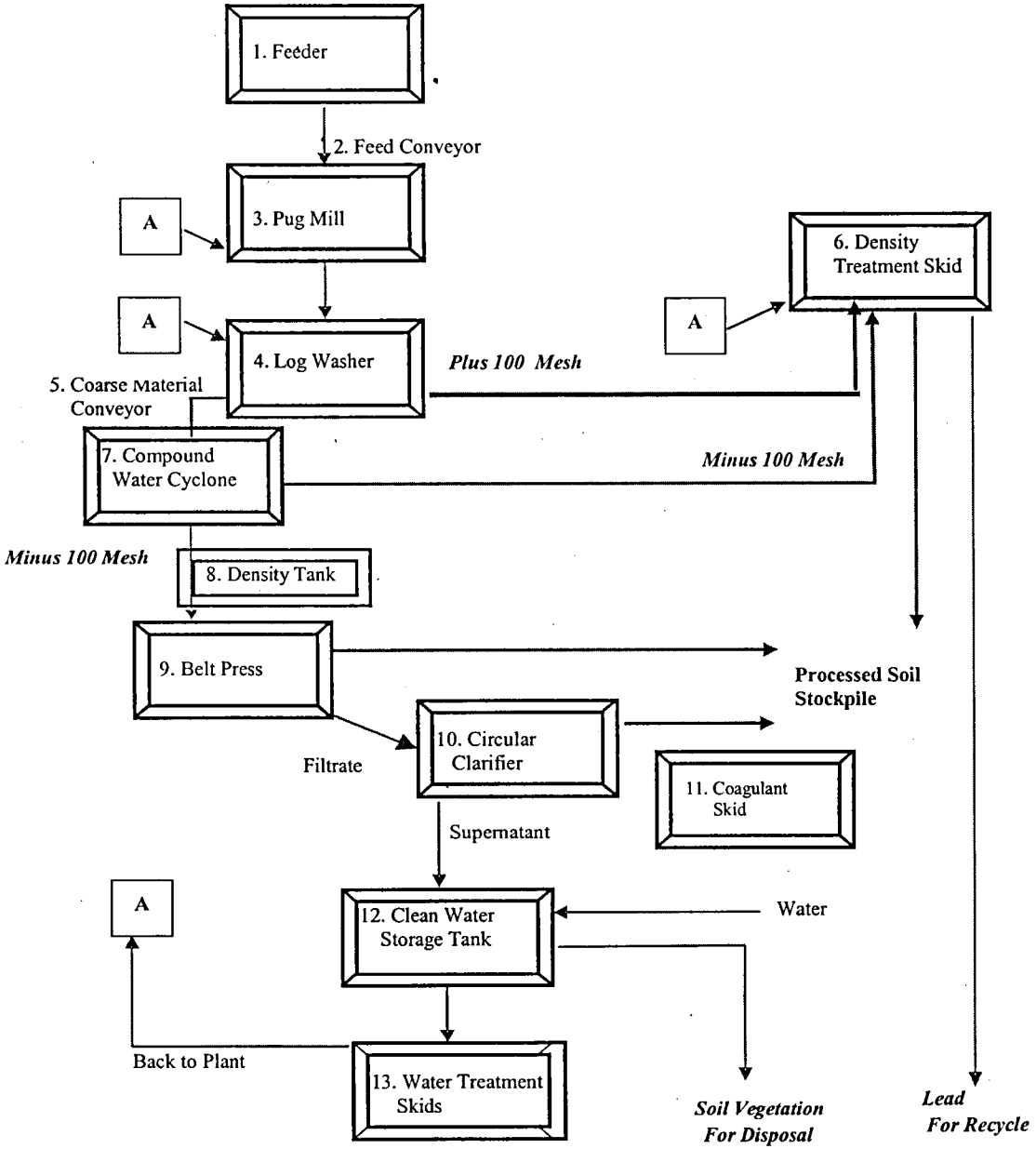
(1) 40 hp TEFC water delivery pump.

13. Water Treatment Skids

(1) 4-pot sand filtration skid and

(1) dual tank activated carbon skid.

Particle Separation Block Diagram



8.2 Field Setup

Assembly of Plant: The physical processing components will be skid mounted, delivered by trailer to the site, and positioned with a loader and crane. Quick disconnects using dripless stainless-steel camlocks will be used on all pressure rated hoses linking the various units. All moving mechanical parts are protected per OSHA regulations, along with proper design of ladders, walkways and railing.

Each module will be inspected for damage prior to system assembly. If damaged components are found, they will be immediately repaired per the manufacturer's recommendations with suitable spare parts. As each module is set, it will receive the following evaluation:

TEST ITEM	REQUIREMENT	ACCEPTANCE CRITERIA
Tanks	Water-tight	No visible leaks
Level sensors	Appropriate level settings	Trip at preset levels
Piping	Water-tight	No visible leaks Within manufacturer's specifications
Pumps	Leak-fee Operate in design range	No visible leaks Within manufacturer's specifications
Conveyors	Operate in design range	No visible leaks Within manufacturer's specifications
Density Recovery Systems	Water-tight Operate in design range	No visible leaks Within manufacturer's specifications
Mechanical Equipment	Operate in design range	No visible leaks Within manufacturer's specifications
Safety Equipment	Functional	No visible damage Within manufacturer's specifications

A spare parts inventory and mobile mechanics truck/machine shop will be maintained on-site to expedite repair and maintenance. Once the particle separation plant is erected, the system will be tested

Shakedown: Prior to start-up of any equipment, an orientation meeting will be conducted for all onsite project personnel. The site orientation meeting will:

- Establish protocols for entering and exiting the work area
- Review overall site activities
- Review details of each specific site task
- Review the Health & Safety Plan
- Identify specific safety concerns

To confirm operational status, the particle separation system will initially be charged with clean water. If all unit operations perform satisfactorily, a small quantity of soil will be processed through the system. All unit operations will be monitored for performance within their design specification as shown below. If performance outside of design specification is noted, the deficient unit will be repaired or adjusted or replaced. The process will be field adjusted, as required, to meet performance requirements, and processing of the particle separation system will commence.

TEST ITEM	REQUIREMENT	ACCEPTANCE CRITERIA
Piping Systems	Leak and pressure test	No visible leaks
Process Arrangement	Conformance to P&ID	Matches P&ID
Pumps	Leak-free Correct rotation	No visible leaks Meets manufacturer's specifications
Safety Services	Test/adjust shutoffs, level adjustments, pressure relief valves	Per manufacturer's specifications
Mechanical Equipment	Test system on/off rotation, direction	No binding, per manufacturer's specifications

9.0 RESPONSIBILITIES, SCHEDULE, AND COSTS

Conceptual costs have been developed for particle separation treatment at the site based on the following division of tasks and responsibilities listed in Table 8 below.

Table 8. Task Responsibilities

Task	Primary Responsibility	Review/Support Responsibility
Project Management		
1. Project Plans	TETRA TECH	Brice
2. Site Management	TETRA TECH	Brice
3. Regulatory Compliance	TETRA TECH	Brice
4. Site H&S, incl. Air monitoring	TETRA TECH	Brice

5. Reporting	TETRA TECH	Brice
Mobilization/Demobilization/Site Prep		
1. Security	TETRA TECH	Brice
2. Treatment Pad	TETRA TECH	Brice
3. Facilities (Office and Break Trailer)	TETRA TECH	Brice
4. Power	Brice	TETRA TECH
5. Water (to Pad)	TETRA TECH	Brice
6. Erosion Control	TETRA TECH	Brice
7. Mobe Processing Equipment	Brice	TETRA TECH
8. Set Up/Shake-Down Plant	Brice	TETRA TECH
9. Demobe Equipment	Brice	TETRA TECH
Particle Separation Technology		
1. Excavation and Haulage	TETRA TECH	Brice
2. Processing	Brice	TETRA TECH
3. Disposition of Metal/Vegetation	TETRA TECH	Brice
4. Sample Prep	TETRA TECH	Brice (training)
5. Rainwater Management	TETRA TECH	Brice
6. Processed Soil Disposition	TETRA TECH	Brice
7. Analytical	TETRA TECH	Brice
8. Final Water Disposition (other than free-discharge)	TETRA TECH	Brice
Restoration	TETRA TECH	

Schedule – 12 to 14 weeks from time of award (NTP) to acquire equipment, gather up consumables and spare parts (first week onsite is approximately Week 14 or 16 following NTP). An exact schedule will be finalized with contract award. A preliminary schedule is shown below in Table 9 showing Task durations.

If the project proceeds, have a Project Kick-Off Meeting to discuss the project and contact all equipment, material, and service vendors identified and inspect gear for quality and lock-in deliveries and availability. Re-visit the site to finalize approaches. Lock in the project schedule. This task is vital to discuss roles and responsibilities of each firm.

The schedule reflects not performing a pilot-scale demonstration. The schedule reflects an approach the involves bringing in large field-scale equipment to perform the work and an extended shake-down period of making equipment adjustments as necessary, to maximize production and efficiency.

Table 9. Anticipated Field Schedule

Task	Duration
Equipment Acquisition	12 - 14 weeks
Mobilization	2 Weeks (1-week onsite)
Plant Set-Up & Shake-Down	6 Weeks
Processing	50,000 yards (75,000 tons) = 234 days
	40,000 yards (60,000 tons) = 188 days
	20,000 yards (30,000 tons) = 94 days
Plant Decon & Demobilization	3 weeks

Note: Based on 6 day per week/10-hr day schedule

Cost Estimates

Costs have been developed for the above three soil quantity scenarios of 75,000, 60,000, and 30,000 tons of soil. The key cost variable is soil quantity requiring particle separation processing. Fixed costs associated with mobilization, set-up and shakedown, and decontamination and demobilization are the same regardless of quantity because the same scale plant is being utilized.

Table 10. Cost and Quantity Information

#1 - 50,000 Yd^3 or 75,000 Ton Minimum Soil Quantity

Item	Description	Total	Cost/Ton
Task 1	Kick-Off Meeting	$4,185.00	$0.06
Task 2	Plans Assistance	$4,752.00	$0.06
Task 2	Mobilization	$209,661.00	$2.80
Task 4	Set-Up and Shakedown	$439,700.00	$5.86
Task 5	Particle Separation	$4,287,943.00	$57.17
Task 6	Decon and Demobilization	$231,074.00	$3.08
Total		**$5,177,315.00**	**$69.03**

#2 - 40,000 Yd³ or 60,000 Ton Minimum Soil Quantity

Item	Description	Total	Cost/Ton
Task 1	Kick-Off Meeting	$4,185.00	$0.07
Task 2	Plans Assistance	$4,752.00	$0.08
Task 2	Mobilization	$209,661.00	$3.49
Task 4	Set-Up and Shakedown	$439,700.00	$7.33
Task 5	Particle Separation	$3,811,004.00	$63.52
Task 6	Decon and Demobilization	$231,074.00	$3.85
Total		**$4,700,376.00**	**$78.34**

#3 - 20,000 Yd³ or 30,000 Ton Minimum Soil Quantity

Item	Description	Total	Cost/Ton
Task 1	Kick-Off Meeting	$4,185.00	$0.14
Task 2	Plans Assistance	$4,752.00	$0.16
Task 2	Mobilization	$209,661.00	$6.99
Task 4	Set-Up and Shakedown	$439,700.00	$14.66
Task 5	Particle Separation	$2,728,630.00	$90.95
Task 6	Decon and Demobilization	$231,074.00	$7.70
Total		**$3,618,002.00**	**$120.60**

Prices depend on reaching mutually agreeable Terms and Conditions. Costs are based on guaranteed minimum process quantities.