

**AUTO SHREDDER RESIDUE  
TREATABILITY STUDY WORKPLAN**

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**CALIFORNIA CHAPTER  
INSTITUTE OF SCRAP RECYCLING INDUSTRIES**

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# **AUTO SHREDDER RESIDUE TREATABILITY STUDY WORKPLAN**

## **1. Framework for Treatability Study**

### **1.1 Description of Auto Shredder Residue**

Auto shredder residue or “ASR” is a heterogeneous mixture of largely non-metallic materials resulting from the shredding of auto bodies, appliances, and other scrap metal materials. An auto shredder is a large, electric-powered hammermill that pulverizes metal into fist-sized pieces which are then sorted by different “downstream” metal separation processes including magnets, trommels, screens, optical scanners, eddy currents, and other types of proprietary process equipment. ASR is the material that remains after ferrous and nonferrous metals have been separated and removed from the various streams comprising the output of the shredder. Shredder output is known as “aggregate” in the industry and is an intermediate process material that contains significant amounts of valuable ferrous and nonferrous metal that is separated and sold as commodities. In contrast, ASR consists primarily of foam, fabric, plastics, rubber, tires, glass, wood, and debris materials, along with minute amounts of remaining metallic material that is too small to be economically separated and removed from the aggregate. Following completion of processing for metals separation and removal, ASR is sent to an in-line treatment system (described below) where it is treated prior to transport off-site, primarily for use as alternative daily landfill cover. Treated material (“TASR”) is subject to a final magnetic screen for removal of residual ferrous material before being stockpiled for eventual transport to the landfill.

ASR is classified and managed as a nonhazardous waste under the federal hazardous waste management program (RCRA) and in most jurisdictions. However, California's hazardous waste classification scheme is more stringent than the federal scheme, and considers wastes, unless exempted or excluded from regulation, to be hazardous if they exceed regulatory thresholds known as Total Threshold Limit Concentrations (TTLCs) or Soluble Threshold Limit Concentrations (STLCs). These limits are established for 17 metals, several of which are commonly found in ASR.<sup>1</sup> The extractable concentration of a metal is determined through application of the Waste Extraction Test (WET), which utilizes a citrate extraction solution which is more aggressive than the acetate solution that is used in the federal Toxicity Characteristic Leaching Procedure (TCLP). The California classification scheme also regulates metals that are not regulated under RCRA, including copper, nickel and zinc. Testing of ASR has shown that it typically contains certain inorganic elements in excess of TTLCs, and certain extractable metals in excess of the STLCs, as determined by the WET. Other state toxicity characteristics (e.g., aquatic toxicity) are not exhibited by treated or untreated ASR.

## **1.2 Regulatory Framework**

Following adoption of the state hazardous waste management program in the early 1980s, the companies that generated ASR developed a means of treating shredder residue through a chemical fixation process that reduces the solubility of residual metals in the waste, rendering it essentially non-leachable under typical solid waste landfill scenarios. A detailed description of the treatment process can be found in the May 2012 report entitled *Treatment of Auto Shredder Residue* by EnviroSure Solutions and Dr. George J. Trezek, Ph.D., a U.C. Berkeley Emeritus Professor of Chemical Engineering who developed the treatment process (hereafter, "Trezek

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<sup>1</sup> The TTLC and STLC do not apply to elemental metals unless they occur in a friable, powdered or finely divided state. 22 Cal. Code Regs., § 66261.24(a)(2).

Report”). A copy of the Trezek Report is provided in Attachment 1. Although the treatment process has been optimized over time, the basic chemistry remains the same. A brief summary of the current treatment process is presented in Section 1.5 below.

Following development of the treatment process, the shredder companies applied to the Department of Health Services (the predecessor to DTSC) to classify treated ASR as a nonhazardous waste on the grounds that the waste possessed mitigating physical and chemical characteristics that rendered it insignificant as a hazard to human health and the environment (see former section 66305(e), Title 22, California Code of Regulations, recodified at section 66260.200(f)). Each application was supported by analytical data that compared the solubility of key heavy metals (primarily lead and cadmium) in the waste before and after treatment, and reclassification was granted by DTSC based on the demonstrated effectiveness of the treatment process in reducing the solubility of the waste. While most companies were originally required to remove mufflers and tailpipes from automobile bodies prior to shredding in order to qualify for reclassification, this condition was later eliminated when it was demonstrated that the treatment process effectively reduced the solubility of metals associated with these automobile parts. A standard of 50 mg/L for lead was established as sufficient for declassification of TASR, given the common occurrence of lead in roadside dirt at an extractable concentration greater than the STLC (5 mg/L) and the fact that under the conditions found in most solid waste landfills, the solubility of lead would be less than 5 mg/L, as demonstrated by modified WET testing using landfill leachate or deionized water. Subsequent analysis of TASR using landfill leachate has shown the extractable lead level to be < 0.5 mg/L (less than one-tenth of the STLC).

Declassification letters were issued to the individual shredder companies during the late 1980s - early 1990s time frame and remain in effect today.<sup>2</sup> ASR is now routinely treated to reduce extractable lead to a WET concentration of <50 mg/L. In the case of at least one southern California shredder, treated ASR is also required to meet the STLC for zinc (250 mg/L) in order to be eligible for classification as nonhazardous waste.<sup>3</sup>

### **1.3 Purpose of Treatability Study**

Although ASR has been treated successfully for many years, this process has proceeded without significant regulatory oversight due to the nonhazardous classification of the material. DTSC is requesting this treatability study as a means of validating the assumptions and conclusions set forth in the Trezek Report and to substantiate the continued classification of TASR as a nonhazardous waste. The results of this study are expected to provide a scientific basis for the establishment of uniform statewide treatment standards that are protective of human health and the environment and that will allow the industry to manage TASR in a beneficial, cost-effective manner, taking into consideration the extremely large volume of material that is generated, the economic realities of the industry, and other factors. The study will also be useful in responding to questions raised by the public regarding the treatment process. This treatability study workplan was prepared in accordance with guidance provided by DTSC.

### **1.4 Unique characteristics affecting auto shredder industry**

ASR is a very high-volume, low hazard waste that is not susceptible to waste minimization beyond the shredders' efforts to remove ferrous metals, nonferrous metals, and other recyclables for which there are existing markets. Industry-wide efforts are underway to increase the removal and marketability of other components of ASR, but these efforts are long-

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<sup>2</sup> These letters are sometimes called "P" letters, based on the subsection of current section 66260.200 that authorizes DTSC to reclassify hazardous waste as nonhazardous.

<sup>3</sup> The specific terms of the declassification letters issued to different auto shredders differ somewhat.

term, dependent on global economic conditions and the ability to overcome regulatory and market hurdles. Simply put, if the cost of treating, transporting and disposing of ASR, per volume of scrap, exceeds the profit derived from the sale of metals and other recyclables from that volume of scrap, the shredder operation ceases to be economically viable. Shredder facilities do not add any hazardous substances to the materials they process, and the companies participating in this study each implement rigorous scrap acceptance policies to ensure that hazardous materials are not inadvertently accepted into the yard. Domestic shredder facilities provide an important public service by separating and recycling valuable resources from the vast sea of metallic discards produced by society, thereby conserving energy, avoiding the need to mine virgin ores, reducing greenhouse gases, conserving limited landfill capacity, and helping to reduce or eliminate urban blight. The societal and environmental benefits that flow from the shredding industry are significant and justify the need for regulatory requirements that are commensurate with the low risk associated with ASR. Despite decades of disposal or placement of treated and untreated ASR in California landfills (lined and unlined), there are no known cases of environmental damage or threats to human health resulting from management of ASR.

Economic studies conducted by independent third parties demonstrate that cost-effective options for management of ASR are important to the survival of the shredder industry in California. Increasingly, the domestic industry is threatened by competition from foreign companies that pay increased prices for end-of-life vehicles and appliances in California and neighboring markets and ship them overseas with minimal or no prior processing. Without the attendant regulatory costs associated with treating, transporting and disposing of ASR, these companies threaten the existence of domestic shredders. It is thus essential that regulations applicable to the management of ASR reflect an appropriate level of treatment, taking into

consideration the inherent characteristics of the material, how the treated material is used, and the very low potential for human or environmental exposure.

### **1.5 General Description of the Current Treatment Process**

The treatment process that has been in use since the latter 1980s is chemical in nature and involves the application of liquid silicates to the final residue. In regulatory terms, this treatment process can best be described as in-line chemical fixation or stabilization.<sup>4</sup> The process is completed with the addition of an alkaline activator such as cement or lime. Previous reports and publications, including the Trezek Report, have been submitted to DTSC which provide detailed descriptions and discussions of the process, including the governing chemical reaction equations.

The treatment is applied after the aggregate has been processed through the downstream nonferrous metal removal system. The initial step in the treatment process is the thorough wetting of the residue by the liquid silicate blend as it enters the pug mill mixer. After the wetted material is thoroughly mixed, the alkaline activator is added and the mixing continues in the remainder of the pug mill screw. Treated material is passed under a metal separator (magnet) for further metal recovery and is then discharged and conveyed into a stockpile where it is accumulated until shipped off-site for use as alternative daily cover. Because of the usefulness of TASR as daily cover, the material is rarely disposed of as a waste.

### **1.6 Variables Affecting Treatment**

The following is a discussion of the principal variables influencing the treatment process:

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<sup>4</sup> According to EPA, “stabilization” encompasses treatment processes that are designed to accomplish one or more of the following: (i) improve the handling and physical characteristics of the waste (e.g., sorption of free liquids); (ii) decrease the surface area of the waste mass across which transfer or loss of contaminants can occur; or (iii) limit the solubility of any hazardous constituents of the waste, e.g., by pH adjustment or sorption phenomena. U.S. EPA (1989). Waste stabilization processes include any physical or chemical process used to reduce the mobility of hazardous constituents in a waste, including mixing the waste with binders or other materials, and allowing the resulting mixture to cure. See 22 CCR § 66260.10.

**1.6.1 Heavy metal concentrations.** The concentration of the heavy metals in the residue is the controlling parameter in establishing the treatment protocol as well as the amount of reduction required to meet a given treatment standards. All shredders process a wide variety of scrap metal, the mix of which varies daily at every facility. Over time, untreated shredder residue generated by one facility is largely indistinguishable from residue generated by another, both in terms of its physical appearance, composition and chemical constituents. Recent data indicate that the ranges of extractable concentrations for the target metals in untreated residue are as follows:

<i>Constituent</i>	<i>Range (mg/L)</i>
Cadmium	0.26 – 1.5
Lead	15 – 75
Zinc	1,550 – 2,000

The inherent variability in the extractable concentrations of these metals in the residue is a function of the mix of scrap being shredded and the efficiency of the metal separation and removal processes employed by the shredders. Although the levels of cadmium and lead have decreased as the composition of car bodies and automotive fuels have changed over time, the levels of zinc in the residue suggest that the amount of this metal being used in the manufacture of commonplace products (e.g., galvanized materials, tires and automotive paints) has increased over time.

**1.6.2 Particle size.** After removal of most ferrous metal by magnetic separation, the aggregate enters the downstream nonferrous removal system, after passing through a screening device. Materials that do not pass a four-inch screen (“plus 4”) are removed and returned to the shredder, and the balance of the material (“minus 4”) is conveyed into the

downstream system for removal of nonferrous metals. The size distribution of the material that enters the treatment system after removal of nonferrous metals follows a Rosen-Rammler distribution where 80% passes 2 inches (50 mm). The 50% passing occurs at approximately 3/4 inch (19 mm), independent of moisture content. The majority of heavy metals reside in the size range below 0.45 inch (12 mm).

When the declassification letters were issued in the late 1980s and early 1990s, it was generally accepted that most of the residual soluble metals in the ASR resided in the small particles or “fines.” Thus, the ASR was separated into two streams — referred to as “fines” and “oversize”— with treatment focusing on the fines. Following treatment, the fines were recombined with the untreated oversize, usually in a 1:1 ratio, and the combined material was sent off-site for disposal or use as ADC. However, no uniform guidelines were established regarding screen size, and different screening practices were followed by the various shredders, influenced in part by the terms and conditions of their specific declassification letters. Over the years, a general consensus has developed within the industry that the treatment process can be applied to all “minus 4” material (i.e., material passing through a 4” screen), thus ensuring treatment of the residual fines contained in what was historically viewed as “oversize” and leading to more uniformity in treatment practices statewide. Material that does not pass through the 4” screen is returned to the shredder.

The industry intends to continue the current practice of treating all ASR that passes through a 4” screen. If the nonferrous metal separation process utilized at a particular facility results in the production of more than one ASR stream, each consisting of different size fractions within the larger “minus 4” category, and such streams are treated separately, the range

of particle sizes in each stream will be evaluated as a variable in the treatment study. If all “minus 4” material is treated in a single stream, particle size will not be addressed by the study.

**1.6.3 Chemical additions.** As previously stated, ASR is treated using a chemical process that fixes the soluble metals remaining in the material. Two reagents are involved: a liquid silicate blend and an alkaline activator. The amount of each addition is predicated on the targeted level of treatment and the concentrations of metals in the residue, which vary over a somewhat predictable range. The treatment is adjusted for values near the high end of the range. A silicate addition of 0.5 gal/ton with 5% cement is a nominal treatment for lead. However, experience has demonstrated that in order to reduce WET-extractable zinc concentrations from 1,650 mg/L to 250 mg/L, the percentage of cement used in the process must be increased to 10% to 12%, more than doubling the cost of treatment.

**1.6.4 Mixing.** A pug mill screw type blender is used for mixing. The wetted residue is mixed in the first 40% of the screw followed by the addition of the alkaline activator. The mixing process is completed in the remainder of the screw. The treated material is discharged onto a holding pile where it is further mixed by a front-end loader as it is being staged for removal from the facility.

**1.6.5 Curing.** The penetration of the silicates into the treated ASR continues throughout the curing process, which can last for several days, as the material resides in the stockpile or is transported to the landfill. However, analytical samples are collected at the end of the mixing screw discharge conveyor indicating that the treatment has been completed. Samples of “cured” TASR are not typically collected or analyzed.

**1.6.6 Moisture content.** The initial moisture content of the residue, typically on the order of 17% to 23%, is a function of the amount of water added during the shredding

process. Moisture is lost as the aggregate courses through the downstream system, but has no effect on the treatment process, which begins with the re-wetting of the material. The fraction of the ASR passing through a 19mm screen (typically 50%) is largely independent of the material moisture content. After treatment the moisture content of T ASR is about 20%.

## **2. Goals of the Treatability Study**

The treatability study, and all conclusions regarding the effectiveness of the treatment process, will be based on analytical data from samples collected and analyzed during the course of the study. However, given the heterogeneity of ASR, recent historical data on the total and extractable concentrations of metals in untreated ASR will also be used in establishing the baseline characteristics of untreated ASR. These historical data will supplement new data, yielding a larger, more statistically robust data base that will ensure a thorough understanding of baseline (untreated) waste characteristics. To address the Department's concern that the characteristics of shredder residue have changed over time as a result of changes in the composition of shredder infeed, recent data will be limited to the timeframe January 2011 to the present to ensure that the ASR is reflective of contemporary shredding operations. No historical data will be used to demonstrate the effectiveness of the treatment process, although new data produced by the study may be compared to existing data on treated ASR for comparison purposes and to gain a more comprehensive understanding of the capabilities of the treatment process.

In addition, the goals set forth below must be demonstrated by each facility seeking continued classification of ASR as a nonhazardous waste. Treatability data from different facilities will not be pooled for classification purposes. All data produced by the treatability study will be presented in the report. Data that are considered to be suspect or unreliable, or that

are excluded from evaluation for data quality reasons, will be flagged and the reason for exclusion explained.

**2.1** Establish the baseline characteristics of untreated ASR, including total and extractable concentrations of all Title 22 metals. RCRA-regulated metals must also be analyzed using the Toxicity Characteristic Leaching Procedure (TCLP). Metals that are not present in concentrations exceeding TCLP, TTLC or STLC values will be excluded from the study. Elimination of specific metals from further consideration will be validated by reference to available historical data, as well as data produced during the study. Based on the industry's experience with the treatment process, lead, zinc and cadmium are expected to be the primary metals studied. As a further validation step, selected samples of treated ASR determined through the study to represent the optimal level of treatment at a given facility will be analyzed for all Title 22 metals, including total and extractable concentrations.

**2.2** Determine whether TARS exhibits any state toxicity characteristic other than exceedance of TTLCs or STLCs for metals, specifically (i) the presence of organic persistent and bioaccumulative toxic substances (*e.g.*, PCBs), and (ii) aquatic toxicity. The purpose of this step is to confirm that TARS does not contain other hazardous constituents that would render the waste hazardous for reasons other than metals.

**2.3** Determine whether total concentrations of metals are affected by the treatment process.

**2.4** Determine whether the treatment process is able to achieve applicable STLCs for the metals identified for treatment.

**2.5** Demonstrate that treatment effectiveness is not a function of simply adjusting the pH of the extraction medium used during toxicity testing.

**2.6** If it can be shown that STLCs can be achieved, determine the relative cost-effectiveness of different treatment formulas that could be used to achieve alternate levels of reduction in solubility. All formulas will be designed to achieve an extractable lead concentration below the STLC of 5.0 mg/L. Initial tests may be conducted on a bench scale, but more promising chemical blends should be conducted on pilot and full-scale bases to demonstrate their continued effectiveness when large volumes of ASR are treated. When scaling tests up or down, care will be taken to ensure that consistent ratios of treatment chemicals (concentrations and/or amount) to waste are maintained. Any changes in the ratios will be noted and explained. Information pertaining to the cost of treatment (e.g., raw material costs, energy costs, sampling and analysis costs, technical support, administrative costs, etc.) is confidential business information and will be handled accordingly.

**2.7** Determine the corresponding zinc concentrations in ASR that has been treated to reduce extractable lead to 5.0 mg/L.

**2.8** Demonstrate that the treatment process will have long-term effectiveness in a landfill environment using appropriate extraction procedures.

### **3. Needed Information**

**3.1 Description of Facility Operations.** While shredder facilities employ the same general types of recycling operations, some differences in equipment or processes may be relevant to the treatability study and will be considered.

**3.2 Compilation of existing data and experience with ASR treatment.** Considerable data exist on the current treatment technology and variations of that procedure. The existing data will be compiled and used to help inform the goals of this study. However, all

conclusions regarding treatment effectiveness will be based on analytical data generated during the course of the study.

**3.3 Descriptions of treatment variables.** It is assumed for purposes of this study that chemical stabilization is the only feasible treatment technology. All forms of thermal treatment have already been evaluated and determined to be infeasible. Critical variables associated with chemical stabilization will be identified and measured.

**3.3.1** The type of treatment chemicals used

**3.3.2** The rate of treatment chemical addition

**3.3.3** The ratio of treatment chemicals to ASR

**3.3.4** Particle size, where relevant

**3.3.5** Evaluation of variants on stabilization/fixation technology

**3.3.6** Effects, if any, of scaling up the treatment process

**3.4 Cost of treatment.** The cost of the treatment options, as described above, will be evaluated. Costs will be considered both independently and in the context of the broader economics of the facility operation, taking into consideration fluctuating prices for raw materials and metal commodities. Treatment costs will include the cost of treatment chemicals and associated management costs (some of this information may be proprietary). Existing economic studies of the shredder industry will be used to the extent currently relevant. As noted above, information pertaining to costs of treatment is confidential business information. Publication of this information is also subject to limitations imposed by federal antitrust laws.

**3.5 Solubility/extractability of metals in TASR under landfill conditions.** The published literature and landfill records will be reviewed to assess the impacts of untreated and

treated ASR in the landfill environment. In addition, modified extraction procedures will be conducted and results will be compared to available landfill data.

**3.6 Toxicity of metals in a landfill environment.** The potential toxicity of ASR in the landfill environment will be assessed, with particular emphasis on cadmium, lead and zinc.

#### **4. Boundaries of the Study**

**4.1** The study is limited to five shredder facilities in California. Once the workplan is approved, each facility will conduct its own treatability study following the approved protocol. A single report will be submitted to DTSC, with separate chapters devoted to individual facility results. Where appropriate, data from each facility will be pooled for statistical analysis and industry-wide conclusions will be drawn.

**4.2** The study is limited to an evaluation of ASR, the residual material that remains after completion of all ferrous and nonferrous metal separation and removal operations are completed. No aggregate samples will be included in the study.

**4.3** The study is limited to an evaluation of the effect of treatment on the solubility of metals that exceed STLC thresholds in the untreated waste. The treatment process is inapplicable to other constituents (e.g., PCBs) that may be contained in ASR.

**4.4** The treatment process does not materially affect total concentrations of metals in the waste, and it is anticipated that total concentrations of lead, zinc and copper will routinely be observed in both untreated and treated samples analyzed during the study.

**4.5** It is accepted practice to manage oversized ASR (“plus 4”) by returning it to shredders for further reduction. “Plus 4” material that is returned to the shredder will not be included in this study. It is possible, however, that random pieces of material exceeding four inches will not be screened out (e.g., odd-shaped pieces of material that exceed four inches in

only one dimension) and will enter the treatment system, along with smaller material. This oversize material will be treated in the same manner as other ASR.

**4.6** When relevant, existing data on prior ASR treatment will be included in the treatability study for purposes of comparison to treatment study results.

**4.7** New data for ASR and TADR as generated by California auto shredders from January 2011 to present will be collected and assessed.

## **5. Analytic Approach**

**5.1 Sample Collection Method.** The following generic procedure will be used for collecting representative ASR material samples that will be used in the treatability study. Consistent with the fact that all ASR material is being treated (both the “undersize” and “oversize”), the sampling point for untreated residue is the location prior to the point where the ASR enters the treatment system. A clean long-handled shovel is placed under discharge stream allowing it to be completely filled with material. This will result in the collection of approximately a 1250 gram aliquot of material. (The weight can be checked with a portable scale). This procedure is repeated at half-hour intervals over two eight-hour operating shifts so that a total of 32 aliquots or 40,000 grams of untreated ASR are collected. As each aliquot is collected, it is placed in a lined and covered 55-gallon drum or other suitably sized container.

When collecting samples of treated ASR for subsequent analysis, the same procedure shall be followed except that the sample shall be collected immediately after the point where the treated ASR passes the final magnet and before it falls onto the stockpile. Samples will not be collected from the pug mill during actual treatment operations for two reasons: (1) the treatment process is not completed until the material exits the mill, and (2) collection of samples from the pug mill, while in operation, would pose unacceptable safety risks to personnel.

**5.2 Sample Preparation.** The sample preparation is predicated on the requirements of the subsequent testing. For a typical test involving the evaluation of chemical additions and extraction procedures, the number of combinations would determine the quantity of subsamples that need to be generated. For example, using the protocol of Table 1, five extractions are called for. Consistent with previous generic treatability studies, three different activator additions are tested for each rate of silicate addition. Thus, evaluating 3 silicate levels requires 9 samples. If 5 extractions and a blank (untreated) are to be evaluated, 54 subsamples are required.

The recommended size of each subsample in a treatability study is 150 grams. The certified laboratory requires 100 grams. The subsamples are generated as follows: the entire contents of the 55-gallon drum are deposited onto a clean thick plastic sheet where it is thoroughly mixed and formed into a cone. Following the cone and quartering procedure, the cone is divided into four quadrants. Opposite sides are removed and set aside. The procedure is repeated for the two remaining quadrants. By this procedure, the size of original sample is reduced to 10,000 grams. This material is spread into a thin layer on a clean plastic sheet divided into equal squares or sections. Material from each section forms the subsamples totaling 8100 grams. Standard sample preparation techniques, as specified in regulation or agency guidance shall be followed and documented. For example, when preparing a Type i waste (millable solids) for analysis by the WET, extraneous, non-friable solid particles that do not pass through a No. 10 sieve (e.g., rocks) are to be removed from the sample and discarded prior to analysis. DTSC guidance indicates that solid metal objects (e.g., coins or similar pieces of solid metal) should be removed from the sample.<sup>5</sup> Given the heterogeneity of ASR, however, care should be taken to ensure that all millable components of the waste stream are represented in the sample matrix. If

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<sup>5</sup> It is also noted that the STLC does not apply to elemental metals unless they exist in a friable, powdered or finely divided state. See 22 Cal. Code Regs., § 66261.24(a)(2)(A), footnote b.

necessary, large pieces of material should be cut as necessary to ensure their inclusion in the sample.

**5.3 Required Number of Samples.** The sampling procedure and preparation must be repeated for each batch of tests. The primary aim of this study is to quantify, to the extent possible, the relationship between the levels of metals, primarily lead and zinc, and the reagent addition treatment parameters. The quantity of total sample required will depend upon the number of subsamples needed for a particular test. A sufficient number of samples shall be analyzed during each batch of tests to adequately reflect the variability in the waste. Each facility will prepare a Quality Assurance/Quality Control Plan which will be used to determine the number of samples required at each stage of testing.

**5.4 Extraction and Test Methods.** The five extraction tests and their procedures are summarized Table 1. All analytical methods must conform with the particular tests that are being run (e.g., if the WET is being run, the procedures in Chapter 11, Appendix II of the Title 22 regulations must be followed).

<i>Extraction/Test</i>	<i>Procedure</i>	<i>Source</i>
Extraction with Acetate Buffer	TCLP	EPA 1311
Extraction with Citrate Buffer	WET	22CCR, Div 4.5, Chapt 11, Article 5, Appendix II
Extraction with synthetic rainwater	SPLP	EPA 1320
Extraction with municipal solid waste leachate (MSWL)	Extraction following the above protocols, but using actual MSWL	
Selected metals in extracts or leachates	Digestion with HCl and HNO <sub>3</sub> , instrumental quantitation	EPA SW-846 6000 series

**Table 1. Extraction and Test Methods**

**5.5 Physical properties.** The physical properties of ASR include:

Moisture content	Measure loss of weight after heating for 1 hour at 105° F.	ASTM D2216-10
pH	pH meter test of 1:1 mixture of sample and water	EPA 9045D
Alkalinity	Titration to pH 4.5	EPA 310.1, modified for solids
Ignitability	Ignitability screening tests	EPA 1030
Friabililty	Qualitative Friability Test with Hand Pressure Sieving of sample with agitation	ASTM C-136

**Table 2. Physical Test Methods for TASR**

## 6. Performance Criteria

**6.1** Existing data will be reviewed to determine consistency with current ASR treatment, considering both changes in ASR composition and changes in treatment technologies over time.

**6.2** New data will be collected using representative samples of the ASR and TASR streams. Where appropriate, the 90% (one-tailed) upper confidence limits will be calculated, and compared with current STLC values and TTLC values.

### 6.3 Limits for decision errors

**6.3.1** The decision rule is: If a treatment method reduces the WET-extractable lead in TASR to less than 5.0 mg/L, it will be judged acceptable.

**6.3.2** Use existing treatment data to calculate the minimum number of samples needed to meet the 5.0 mg/L lead STLC with a 90% (one-tailed) confidence level. Table 3 shows the results for prior treatability tests. As shown, all of the UCLs for extractable lead in TASR are less than the STLC. Assuming similar means and standard deviations in additional data, four samples per treatment batch is adequate to meet the required confidence level.

		Lead	Lead	Zinc	Zinc
Activator %	Silicate gal/ton	Untreated	Treated	Untreated	Treated
		mg/L	mg/L	mg/L	mg/L
5-6	0.50	43.2	2.41	1668	642.0
5-6	0.50	39.4	4.04	1700	898.0
5-6	0.50	40.4	2.25	1440	570.0
mean		41.0	2.90	1603	703.3
sd		2.0	0.99	142	172.4
<i>N</i>		3	3	3	3
<i>T</i>		1.886	1.886	1.886	1.886
90% UCL		43.1	3.98	1757	891.0
10-12	0.55	40.0	1.07	1530	19.7
10-12	0.55	33.8	1.45	1900	46.0

10-12	0.55	27.1	2.70	1560	88.2
10-12	0.55	34.8	0.49	1590	5.2
mean		33.9	1.43	1645	39.8
sd		4.6	0.81	149	31.5
N		4	4	4	4
T		1.638	1.638	1.638	1.638
90% UCL		37.7	2.09	1767	65.6
7-9	0.35	17.7	0.81	1610	5.4
7-9	0.35	61.8	2.11	1770	600.0
7-9	0.35	24.9	0.54	1600	6.7
7-9	0.35	28.9	2.03	1530	447.0
mean		33.3	1.37	1628	264.8
sd		16.9	0.70	88	264.3
N		4	4	4	4
T		1.638	1.638	1.638	1.638
90% UCL		47.2	1.95	1699	481.3

**Table 3. Prior Treatment Results**

**6.4 Management of Treatment Residuals.** Treatment residuals are expected to exceed total and certain soluble threshold limits. As a conservative measure, all treatment residuals will be managed and disposed of as non-RCRA hazardous waste.

## 7. Treatability Study Methodology

**7.1 Untreated Material.** The initial phase of the study will deal with the characterization of the untreated ASR. An appropriate amount of material will be collected and prepared according to the procedure described in section 5 so that samples can be submitted for the following tests. These will include: (a) the total concentration of all regulated metals; (b) the extractable concentrations of all regulated metals using each of the extraction tests specified in Table 1; (c) PCB's; and (d) the aquatic toxicity bioassay.

These results will be compiled and analyzed in terms of their bearing on the subsequent treatability study. For example, years of similar testing have shown that the principal metals of interest are lead, cadmium, and zinc. In terms of ASR, the other thirteen metals are either not

detected or are well below the regulatory limit. All metals that are determined to be non-detect, or that are present at total concentrations less than 10 times the relevant STLC, during the initial round of testing will be eliminated from the study.

**7.2 Laboratory Analysis.** All samples will be sent to a certified laboratory for analysis. In this case, all participants will use the CalScience Laboratory in Garden Grove in order to eliminate potential variability among laboratories. Duplicates of 20% of the samples submitted to CalScience for analysis will be submitted to Bodycote Labs in Santa Fe Springs, within allowable holding times, for duplicate analysis. The final report will include the results of all duplicate samples. Given the inherent variability in the waste, duplicate results themselves may vary.

**7.3 Treatability Study.** The details of the treatability study are given in terms of the effect of reagent additions on the extractable levels of regulated metals, application of appropriate statistical analysis and subsequent correlations between metals and reagents and the long-term efficacy of treatment.

**7.3.1 Reagent Additions.** This portion of the study will deal with quantifying the change in metal concentrations as a function of the amount of silicate and alkaline activator addition using the STLC extraction method. Although this treatability portion of the study will be performed as a series of laboratory bench scale tests, it will be reflective of the work shown above in Table 3. In this table, the results of a treatability study with a similar goal, conducted at a commercial California auto shredding facility, are summarized for extractable concentrations of lead and zinc in terms of reagent additions.

The initial series of tests will be conducted as follows: The sample preparation protocol as described in Section 5 will be followed. The specific reagent concentrations will be:

(a) silicate at 0.25 gal/ton and cement at 5%, 7% and 10%; (b) silicate at 0.35 gal/ton and cement at 5%, 7%, and 10%; and (c) silicate at 0.5 gal/ton and cement at 5%, 7%, and 10%. In terms of the subsequent statistical analysis, five 150 gram samples or mixtures will be prepared for each combination of silicate and activator addition. As indicated above, only one type of extraction will be performed in this phase of the study. A sufficient number of samples will be analyzed to ensure the reliability of the results.

The sequence of treatment is as follows: (a) 150 grams of ASR sample is placed in a 500 ml clear food grade plastic container with a sealable lid; (b) the amount of silicate corresponding to a particular concentration is then mixed into the material. For example, in terms of the above range of silicate addition, for a 150 gram sample, on the order of 1 to 2 grams of silicate are added to about 35 ml of water (a carrying agent) to insure thorough wetting of the material. The mixing time is typically one minute and can be accomplished with a laboratory stirrer or by simply attaching the sealable lid and vigorously shaking the contents so that the material is thoroughly wetted by the silicate water blend; and (c) the treatment is completed with the addition of the alkaline activator and subsequent mixing. For activator additions of 5% to 10%, the amount of added activator will be 7.5 to 10.0 grams. The mixing process is similar to that previously described and is intended to thoroughly incorporate the activator into the wetted material. The treated sample is then allowed to cure several hours and is then prepared according to the extraction procedure for certified laboratory analysis. Discrete samples of treated material will be submitted for analysis. Samples will not be composited beyond the compositing that necessarily occurs as part of the sample collection process.

Upon completion of bench scale testing, those treatment formulas that are selected for further evaluation will be scaled up from bench-scale to full-scale field implementation,

taking into consideration reagent storage and delivery methods, measurement of the amount of reagent delivered to the treatment process, the consistency of test results when compared with bench-scale results and historical data, any differences in mixing or curing times or methods, and other quality assurance considerations.

Subject to claims of business confidentiality, the report will describe each treatment chemical and reagent and will provide copies of MSDSs where available.

**7.3.2 Correlation of Results.** Analytical results from all discrete samples will be included in the report. The statistical analysis as described in section 6 will be applied to the results of the treatability study data and correlated in a manner similar to that shown in Table 3. Based on experience, it is likely that the lead, zinc, and cadmium will be the metals of greatest interest. The results will be grouped according to percent activator and silicate addition. The data analysis will focus in particular on determining the minimum level of treatment required to consistently achieve the STLC for lead (5 mg/L), and how that compares to the minimum level of treatment needed to consistently achieve the STLC for zinc (250 mg/L). The relationship between extractable lead and zinc can be seen in historical treatability sample results included in Table 3.

**7.3.3 Further Treatability Studies.** If any portion of the treatability data is shown not to be statistically relevant due to a lack of samples, that portion of the treatability study will be repeated using a greater number of samples. The correlation procedure of section 7.3.2 will also be repeated. Depending upon the results of the initial test, additional combinations of activator and silicate may be treated. The combinations would most likely be at finer increments within each group. The correlation would then be repeated. It is also important to

note that the sample collection procedure must be followed in accordance with additional treatability studies.

**7.3.4 Additional Extractions.** The extractions other than the STLC (WET) given in Table 1 will be used to evaluate the leaching characteristics of samples treated with the optimal combination of reagents. As previously mentioned, this is the treatment combination that results in lead levels under 5 mg/l by the STLC test. Additional treated samples will be prepared with this reagent combination so that the four other extractions can be performed. A correlation of the leaching characteristics will be assembled.

**7.3.5 Long Term Efficacy of Treatment.** The long-term efficacy of the treatment will be demonstrated through the application of the Multiple Extraction Procedure (MEP). This test deals with evaluating the immobility of treated heavy metals in an acid rain environment. The Environmental Protection Agency (EPA) uses this procedure to simulate long-term leaching up to 1000 years. The test is designed to approach the natural continuous replacement of fresh leachate that occurs in many hazardous waste landfills. The details of the test procedure are given in the Federal Register/Vol.47, No. 225/Monday, November 22, 1982, page 52687 and also in Appendix 2 of J. R. Conner. The procedure calls for performing ten consecutive extractions with an extracting fluid consisting of a 60/40 weight percent mixture of sulfuric and nitric acid added to distilled deionized water until the pH is 3.0+/-0.2.

This procedure will be applied to a batch of five samples of treated material that has been demonstrated to contain less than 5 mg/l extractable lead (WET STLC). The initial values of the extractable metals in the sample are obtained from the untreated material. The results of the extractions will be analyzed in a format that shows the change in extracted metal concentration as a function of the number of successive extractions. Previous MEP testing of

treated material similar to ASR indicated that an equilibrium concentration was reached after the second extraction and remained unchanged with successive extractions whereas the untreated material continued to ionize and leach. Further details of this process are given in the references.

Comparable series of tests will be run using deionized water and landfill leachate to demonstrate long-term effectiveness of the treatment in a solid waste landfill.

**7.4 Correlation between Soluble Lead and Zinc.** Determine the relationship between extractable lead and extractable zinc, and the relationship between cost and extractable zinc concentration.

**7.5 Statistical Analysis.** Calculate appropriate statistical measures, e.g., mean and upper confidence levels of all extraction results.

**7.6 Evaluation of Costs and Other Environmental Considerations.** Evaluate relative costs of treatment scenarios, as described above. This evaluation will seek to determine the cost differential between a level of treatment that achieves current STLC values for all metals of interest and alternate levels of treatment. Much of the information used for this evaluation will be confidential business information and/or subject to limitations imposed by the antitrust laws. In addition, other potential environmental impacts associated with different levels of treatment will be evaluated on an industry-wide basis, including increased energy, greenhouse gas emissions, fuel consumption, and transportation-related emissions associated with transportation of raw materials and treated ASR.

## **8. Schedule.**

The Treatability Study will be conducted by each facility according to the timeline presented in Table 4 below. Adjustments to this schedule may be made to accommodate site-specific considerations. The interim dates are considered goals or milestones, not enforceable deadlines.

<b>Task</b>	<b>Completion Date</b>
Baseline characterization of untreated ASR	December 31, 2013
Design treatment scenarios	March 31, 2014
Conduct treatability studies	June 30, 2014
Data analysis and preparation of report	August 31, 2014
Submission of final report to DTSC	September 30, 2014

**Table 4. Study Schedule**

## 9. References

Guatney, Mark J., and George J. Trezek, "Treatment of Auto Shredder Residue," May, 2012.

U.S. EPA, "Stabilization/Solidification of CERCLA and RCRA Wastes," May, 1989.

U.S. EPA, "Technology Performance Review: Selecting and Using Solidification/Stabilization Treatment for Site Remediation," EPA/600/R-09/148, November 2009.

U.S. EPA, "Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4," 2006.

Conner J. R , " Chemical Fixation and Solidification of Hazardous Wastes," Van Nostrand Reinhold, New York, 1990.

Trezek G. J, " Remediation of Heavy Metal Contaminated Solids Using Polysilicates," Chapter 20 of Process Engineering for Pollution Control And Waste Minimization, edited by Wise, D. J and Trantolo, D. J, Marcel Dekker, Inc., New York, N.Y.

## *Glossary*

ASR	Auto Shredder Residue
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DTSC	California Department of Toxic Substances Control
RCRA	Resource Conservation and Recovery Act
SPLP	Synthetic Precipitation Leaching Procedure
STLC	Soluble Threshold Limit Concentration
TASR	Treated Auto Shredder Residue
TCLP	Toxicity Characteristic Leaching Procedure
TTLC	Total Threshold Limit Concentration
WET	Waste Extraction Test