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CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN CALIFORNIA

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ABSTRACT

Signed into law in 1989, the California Integrated Waste Management Act requires each California city and county to divert 25% of solid waste generated by 1995 and then 50% by the year 2000 through activities such as source reduction, recycling, composting, and transformation. One of the first mandated actions to be taken by local governments was to conduct a representative solid waste characterization study to determine the types and amounts of materials disposed. By doing this, solid waste management planners could target key waste types for diversion, set waste management goals, and track progress towards those goals. But because many jurisdictions were unfamiliar with waste characterization studies, a wide range of characterization techniques and methods were used which made it difficult for county and state officials to compile and compare results at regional or statewide levels. Many of the initial studies that were conducted used vague material type definitions, inconsistent segregation techniques, and unreliable health and safety plans. Also, as new businesses became more involved in waste management, basic questions were asked about the waste stream that could not be answered by some early studies. So in response to new legislation, the California Integrated Waste Management Board (CIWMB), in conjunction with the University of California at Los Angeles, and an advisory group of 38 public and private sector professionals is developing a new comprehensive waste characterization method for local governments to use that introduces statewide consistency in the process of conducting waste characterization studies. This, in turn, is expected to yield useful information at the local level that can also be easily compiled with other local government results to produce regional or statewide information on the makeup of the solid waste stream.

INTRODUCTION

Solid waste can include putrescible and nonputrescible solid, semisolid, and liquid wastes including garbage, trash, refuse, paper, rubbish, ashes, industrial wastes, demolition and construction wastes, abandoned vehicles and parts thereof, appliances, dewatered sewage sludge which is not hazardous waste, manure, vegetable or animal solid and semisolid wastes, and other discarded solid waste and semisolid waste (California Integrated Waste Management Statutes, 1994). Operations, liability, and regulations, however, may limit the types of solid waste a facility will accept. To date, the State of California has 255 landfills and 3 waste-to-energy facilities. In 1994 these facilities disposed of or combusted approximately 34 million tons of solid waste. Waste diversion efforts recovered approximately 11 million tons of material in that same year resulting in an estimated 25% diversion rate (BioCycle, 1995). The State of California has 527 jurisdictions, each responsible for achieving the mandated diversion goals. In order to meet the 50% diversion goal by the year 2000, state and local officials will need to work together to understand the makeup of 34 million tons of solid waste so that appropriate solutions can be implemented.

DEVELOPING UNIFORM MATERIAL TYPE CATEGORIES

In analyzing the results from the first waste characterization studies, it was clear that compiling information on a statewide basis would be difficult and that any statewide results derived from the compilation would need to be supported with a long list of assumptions. This was due, in part, to inconsistencies in forming material type categories and definitions that characterized the makeup of a waste stream. To address this problem, new standard material type definitions are being developed and will be incorporated into regulations for statewide use. Research was conducted on material types and definitions while various solid waste managers and recyclers provided technical expertise for development of the current draft types and definitions. The draft regulations are currently being circulated and public input will be incorporated into the final regulations.

Waste streams can be classified in two ways: general and specific. General classifications establish basic **material categories** such as paper, plastic, glass, metal, organic and inorganic material. Specific classifications go well beyond the basic material categories. For example, the material category "paper", could be broken down into the following **material types**: corrugated cardboard and paper bags, newspaper, office paper, mixed paper, and remainder/composite. The material type, "office paper", can be broken down further into the following **material sub-types**: white ledger, colored ledger, and computer paper. Waste sorts can be performed at various levels of detail depending upon the material classifications used for categorization. Solid waste planners prefer to set their own level of characterization detail according to local needs. This need for flexibility must be balanced with the need for standardized data collection. The State of California has determined that some level of standardization is necessary to be able to compare, combine, and otherwise use the data beyond the local level. This balance can be achieved by using standard material categories, types and subtypes which can be aggregated (grouped) and disaggregated (split) into various levels of detail. Determining the level of detail needed for data collection is one of the most important decisions in designing a waste characterization study.

Material Categories

The number of material subtypes that comprise a solid waste stream can be substantial. Material classifications shall continue to change as new products are developed and disposed. In developing California's uniform material type categories list, issues such as contamination and market specifications for recyclable materials were evaluated. Review of past characterization studies show that in developing successful diversion programs, a solid waste planner must have an understanding of the market requirements for recovered material. The following is a draft list of the proposed standardized material classifications for California (Draft Regulations, 1995):

DRAFT LIST OF MATERIAL CLASSIFICATIONS FOR CALIFORNIA

Paper
(a) Corrugate Cardboard & Paper Bags
  (1) Uncoated Cardboard
  (2) Coated Cardboard
  (3) Brown Paper Bags
(b) Newspaper
(c) Office Paper
  (1) White Ledger
  (2) Colored Ledger
  (3) Computer Paper
  (4) Other Office Paper
(d) Mixed Paper
  (1) Magazines, Catalogs
  (2) Phone Books
  (3) Other Mixed Paper
(e) Remainder/Composite

Glass
(a) Clear Bottles & Containers
(b) Colored Bottles & Containers
  (1) Green
  (2) Brown
(c) Flat Glass
(d) Remainder/Composite

Other Organic
(a) Food
(b) Yard/Landscape
  (1) Leaves & Grass
  (2) Prunings & Trimmings
  (3) Branches & Stumps
(c) Agricultural Crop Residues
(d) Manures
(e) Wood
(f) Textiles
(g) Tires
(h) Remainder/Composite

Household Hazardous Waste
(a) Paint
(b) Automotive Fluids
(c) Batteries
(d) Remainder/Composite

Plastic
(a) HDPE[1]
  (1) Natural HDPE
  (2) Colored HDPE
(b) PETE[2]
(c) Film Plastic
(d) Other Plastic
  (1) PVC[3]
  (2) PP[4]
  (3) PS[5]
(e) Remainder/Composite

Metal
(a) Ferrous Metal
  (1) Tin/Steel Cans
  (2) Other Ferrous
(b) Non-Ferrous Metal
  (1) Aluminum Cans
  (2) Other Non-Ferrous
(c) White Goods
(d) Remainder/Composite

Other Inorganic
(a) Inerts
  (1) Rocks
  (2) Concrete
  (3) Brick
  (4) Soil & Fines
  (5) Asphalt
  (6) Gypsum Board
(b) Remainder/Composite

Special Waste
(a) Ash
(b) Biosolids
(c) Treated Medical Waste
(d) Bulky Wastes
(d) Remainder/Composite

Mixed Residue

To summarize, the draft list contains nine material categories, 36 material types, and 30 material subtypes. The total number of potential sorting categories without customization is 58.

[1] Polyethylene Terephthalate (PETE)
[2] High Density Polyethylene (HDPE)
[3] Polyvinyl Chloride (PVC)
[4] Polypropylene (PP)
[5] Polystyrene (PS)

APPROACH TO AGGREGATION & DISAGGREGATION

A general rule of performing waste characterization studies is to utilize more detailed material subtypes because the more detailed subtype classification can always be aggregated into the less detailed, more generic material types. The more extensive and detailed the data, the more analytical options that become available. The usefulness of the more detailed data should be balanced against the increase in cost and time required to obtain such data.

Disaggregation

If a specific material is targeted for diversion, a disposal ban, or monitoring for the purpose of evaluating the impact of a diversion program, the specific material should be identified and made part of the waste composition study. If the targeted material already falls under an existing material type or subtype, it should be separated or disaggregated out from the broader classification for sorting. Generally, the additional specific material subtype should be a subset of an existing broader material type which already includes the subtype. The material subtype that is disaggregated from a broader material type and added to a waste composition study should also be capable of being aggregated to a minimum set of standard material types.

A custom material subtype that might be a combination of several material types may need to be created. In this case, data on the custom subtype should be kept separate and identified within each material type. This is done so that the data can be reallocated back or aggregated back to each original broader category. An example of a custom subtype which is found in several broader materials is "plastic wide mouth containers". This subtype can contain both PETE wide mouth containers and HDPE wide mouth containers. The custom subtype should be identified within each separate sub-type - PETE and HDPE. This will allow for the option of combining back into PETE and HDPE separately.

The following questions should be considered when determining whether an additional material subtype or custom subtype should be developed:

- Could the item be targeted for a specific source reduction, recycling, or other diversion program?
- Is the item of sufficient quantity for a diversion program?
- Is the item of significant quantity that it should be identified?
- Is the item easily recognizable and identifiable (for separation purposes)?
- Is the item easily separated during waste composition studies?
- Will the item be contaminated by other disposed material through normal use?
- Are there any significant technical, political, health and safety, or programmatic reasons for identifying the item?

Aggregation

When detailed material composition data is not required, the more detailed material subtypes can be combined into broader material types. Material types can also be combined into even broader material categories for easier classification. Aggregation of the detailed classifications will reduce the number of sorting categories and simplify a waste characterization study. When combining detailed classifications into more generic material categories, the aggregate material category should have one or more of the following characteristics:

- When performing a visual waste characterization, the aggregated categories are the best balance between accuracy and ease of performing the visual sort.
- Aggregate classification is a commonly accepted material category or type.
- Aggregate classification has technical, regulatory, or policy significance.
- Aggregate classification data is useful for achieving a diversion goal.

Sampling time need not be a significant factor in deciding whether or not to use more detailed material classifications for sampling. Time estimates from field supervisors indicate that an experienced sorting crew of 3 or 4 persons can complete an average physical sort in which a 200-300 pound waste sample is sorted into 30 to 40 different classifications in approximately 20 to 30 minutes. The additional time required to physically sort the same sample into 90 to 100 different material types may take up to an additional 5 to 10 minutes per sample. When a sample is divided up into more detailed material subtypes, many of the additional material subtypes will not be present in the sample, and this helps reduce sorting time.

Flexibility & Consistency of Data

It seems to be more advantageous to have more detailed subtypes defined so that data can be manipulated in various ways to assist those entities requesting information. However, it is the solid waste planner that must determine, at the outset, the purpose of the study and its potential uses. Detailed subtypes should be set up so that they can be aggregated into larger categories to ensure consistency of data between characterization studies done at different levels of detail. This balances the need for jurisdictions to have more flexibility in designing their studies with the need for consistency of data across a county or state.

A jurisdiction may design custom subtypes, as long as they are designed so that the data collected can be aggregated into the standard material types. A minimum level of detail should also be established to ensure that the data collected meets a minimum consistency across the state. For example, data collected on metals could be at the minimum level of material types (i.e. ferrous metals and nonferrous metals types) rather than at the category level (metals) to provide consistent, meaningful data across the state.

WASTE CHARACTERIZATION HEALTH & SAFETY PROGRAM

The types of things that can go wrong in the field when sorting crews aren't protected or aware are numerous. Physical, chemical and biological hazards all pose a risk to field personnel. Specific hazards that are known to occur in the field include:

- Exposure to biohazardous, household and other hazardous materials;
- Physical risks from handling broken glass, hypodermic needles, razor blades and other sharp items;
- Animal and/or insect bites;
- Back injury;
- Heat stress and fatigue;
- Traffic and heavy equipment.

These hazards can be managed through controls such as administrative engineering and personal protective equipment. A health and safety protocol is being developed by the CIWMB to aid jurisdictions when conducting local studies; however, each local jurisdiction will be responsible for developing specific safety guidelines appropriate for their particular study. Personal protective equipment may include:

CHECK LIST

√ Industrial First Aid Kit;
√ Field Blanket;
√ Eye Wash Kit;
√ Snake Bite Kit;
√ Moist Disposable Wipes;
√ Rubber Cut Resistant Gloves;
√ Inner Latex Gloves;
√ Hearing Protection;
√ Chemical Goggles or Safety Glasses with Splash Shields;
√ Dust Masks;
√ Light Weight Tyvek Overalls;
√ Hard Bottom, Non-Slip, Steel Toe Shoes;
√ Fire Extinguisher;
√ Site Specific Safety Plan;
√ Supportive Back Belt for Heavy Lifting;
√ Water and Cups.

Site Health & Safety Plan

At least one on-site employee should be designated the Site Safety Officer responsible for ensuring that proper procedures are implemented by personnel in a safe manner and that proper personal protective equipment is made available. Before commencing field work, the Safety Officer should prepare a written plan describing on-site health and safety procedures as well as emergency response procedures. The Plan should be routinely discussed and all safety training should be documented with signatures from all employees. A plan should, at least, discuss the following:

a) Safety equipment to be used during on-site activities.
b) Health and safety procedures to be followed in the field.
c) Procedures to be followed in cases of emergency.
d) Appropriate emergency phone numbers.

The Safety Officer should ensure that all field personnel have read and signed the master copy of this document and always make a copy of the document available at all times. The Safety Officer should periodically check that all site personnel have received training on waste characterization methods, recognizing hazardous wastes, the potential risks from handling hazardous materials, managing site traffic, controlling contaminants, and back injury prevention.

Duties and responsibilities of the Site Safety Officer typically are to:

- Maintain the Site Health & Safety Plan.
- Ensure that the guidelines, rules, and procedures in the document are followed for all site work.
- Be familiar with local emergency services, and maintain a list of emergency phone numbers.
- Conduct tailgate health and safety meetings before and after each work day to discuss the day's safety issues, possible solutions and any suggested changes in the protocol.
- Monitor on site hazards and the early health warning signs (e.g., heat stress/stroke, dehydration, or fatigue) of site personnel.

- Have completed and is certified in an accredited health and safety training program.

At the end of each shift, all site personnel should remove and properly dispose of all disposable clothing and shower at the end of each shift.

WASTE CHARACTERIZATION SAMPLING PROTOCOLS

In the field, sorting crews must adhere to a strict guideline of policies and procedures when performing waste sorts, especially at locations where there is ongoing business operations. Generally, there can be no eating, drinking or smoking during sorting activities. Food and liquids are to be stored away from the sorting areas. Also, no attempt should be made to identify unknown chemical substances present in the waste stream such as pesticides or unmarked household hazardous wastes.

Physical Sorts

When handling waste materials, dangers exists that can affect the health and safety of a single person or the entire crew. Therefore, it is important to establish a "buddy system" where waste sorters are grouped into pairs and each member is to periodically assess the physical condition of his or her buddy.

Sorting tables should be placed away from normal site operations with colored sorting buckets placed around the tables so that the buckets that receive the most material are nearest to the table. To reduce reaching distances, all buckets within a broad material category (i.e. paper) should be positioned close together.

No practical or significant gain in precision is obtained by using weights of more than 200 pounds per sample (Klee, Carruth ASCE Journel, Volume 96, pg. 945-954 8/70). A random sample to be sorted should weigh between 200 and 300 pounds. Begin the sort by removing and characterizing the largest, bulkiest materials first. Sort the remaining items into the material types shown on the sample sheet. If a bucket becomes full, the full bucket is weighed, the data recorded on the data sheet, and the bucket is emptied and reused. Weigh and record the total mass (contents and bucket) on the data sheet. Record the types of buckets used so that later, the weight of the buckets can be subtracted from the total weight. Some weighing scales record tare weights; therefore, if all buckets are of the same size and make, the crew leader may program the scales accordingly.

When a sorter has a question regarding the material type into which an element should be placed, the crew leader should be consulted. For composites or material items, the predominant material type (as measured by weight), determines which material type it belongs. If an item is judged to be recyclable or a potential target for a diversion program, that item should be placed in the "highest value" recyclable category into which it can reasonably be placed. This is sometimes referred to as the "highest common denominator protocol". If the item is judged to be non-recyclable, it should be placed in a non-recyclable, "lowest value" material type into which it fits. After a sample is sorted, the materials that are too small to be sorted can be put into the "Mixed Residue" category.

Visual Sorts

Visual sorts can be conducted swiftly, easily and usually by one or two persons. Visual sorts are performed on waste loads that contain large quantities of bulky or heavy items, consist of materials too small to be sorted, consist of materials that may be too dangerous to sort, or are of primarily one material type. When conducting a visual sort, the load should be closely inspected to ensure that the material type is consistent and identifiable. Photographs or slides can be taken to document waste types or used when other constraints such as odor or business hours inhibit field sampling. Pictures should be taken from as close to a vertical position as possible above the spread-out sample.

Statistical Number of Samples

It is practically impossible, a well as physically undesirable, to separate, measure, and analyze all of the solid waste generated at a specific source or disposed of at a particular facility. Statisticians are tending to use a much broader range of probability and estimating concepts today than has been true historically. Before World War II, estimates of probabilities and quantitative variables were assumed to be legitimate only if they were determined by classical mathematical methods applied to information obtained from random samples. Judgment samples were described and infrequently used, but were not considered to be in the same class with samples selected through random processes. Human experience or judgment in most cases was rejected outrightly as inherently biased. In the last decade, however, the use of judgment samples has been found to be an extremely helpful device in the estimating process. No longer are subjective estimates ridiculed because they do not meet classical definitions. More and more, statistical methods are being developed to meet the real needs of problems that cannot be solved by straight-jacketed classical techniques. Accordingly, when one attempts to obtain random samples from vehicles, the pragmatic person will reject the random sample that contains a dead horse if he does not perceive that the material contains other dead horses as well. This is not only common sense, it is good statistics as well, (Klee, Carruth ASCE Journel, Volume 96, pg. 945-954 8/70).

By law, California's Uniform Waste Characterization Method must be statistically representative and reflect seasonal variation. To this date, several statistical methods have been researched and their applicability is currently being reviewed.

WASTE CHARACTERIZATION EQUIPMENT

Along with the safety equipment described earlier, sorting equipment may include:

WASTE CHARACTERIZATION EQUIPMENT CHECK LIST

√ Front Loader (Bobcat);
√ High Visibility Traffic Cones;
√ Knife with a Fixed Blade;
√ Small Bins or Buckets of various colors (5 gallon or larger) for weighing sorted materials;
√ Folding Sorting Table approximately 4 feet by 6 feet;
√ Plastic Sheeting to place on the work area for easy cleanup;
√ Scale that is accurate to one tenth of a pound;
√ Hand Rake and Prodding Stick;
√ Permanent Markers;
√ Clipboard and Data Sheets;
√ Large Magnets;
√ Calculator;
√ Trash Bags;
√ Cellular Telephone and Two-way, Hand Held Radio;

Waste Characterization Data Sheets

Of critical importance to a waste characterization study is the data sheet. The data sheet is the official site record for information obtained about the characterized waste and the conditions under which characterization occurred. The amount of information that can be obtained in the field is enormous; however, sorting crews are subject to various constraints, the most significant being time. Data sheets should be developed to record data that, when compiled, will provide planners with information by which to make decisions. Frivolous data should be avoided. Data sheets should be clear and easy to fill out. Enough space should be provided so that sorters can relatively easily place data in the appropriate locations. Data sheets should be limited to one page (double-sided if necessary).

The following data is typically recorded:

- Date, location, weather conditions;
- Waste generator or generator category (i.e. residential, commercial, industrial, agricultural);
- Weight of each material that is sorted;
- Special notes section.

CHARACTERIZATION METHODS

Default Data Base

One important and unique facet of California's Uniform Waste Characterization Method is the development of a waste characterization database, which is being designed to eventually provide local governments the option to use "default" data in analyzing the waste stream, when collecting field data is not feasible. Specific uses for the database that have been identified so far include:

- Identifying the largest generators of specific materials targeted for diversion programs.
- Redesigning collection routes to change a traditional disposal collection route to a high grade (recyclables - rich) route.
- Multi-jurisdictional waste shed composition and quantity estimates used for designing a regional material recovery facility.
- Estimating waste composition and quantities for a new development projects.
- Projecting changes in waste stream composition and quantities given a significant change in the commercial/industrial makeup of an area.

Since the types of residences, businesses, and industries in a jurisdiction determine the characteristics of its waste stream, one goal of the database is to develop detailed information about waste generators and what they dispose. Several commercial business databases for California were purchased and have been incorporated into the initial database. All businesses in the state are listed with name, address, ZIP code, SIC code, number of employees, and gross sales volume. Also, waste characterizations performed at the generator level are being conducted and information shall be included into the database. For maximum flexibility in data use, the database incorporates data from individual generators rather than gross sector data for the non-residential waste stream. Data is organized according to 38 groupings or "subpopulations" of similar businesses formed from 2-digit Standard Industrial Classification (SIC) codes. All businesses in a jurisdiction can be classified and grouped into these subpopulations and the dominant business types can be determined from the number of employees in each subpopulation.

A distinct waste composition profile for each subpopulation has been developed from sampling data from individual businesses. A "correlative factor" which correlates waste disposal quantities to the number of employees (for example, tons/employee/year) has also been developed for each subpopulation. The quantity data has been gathered from limited preliminary field sampling of individual businesses, and from detailed route information provided by waste hauling companies in California. By combining the composition profile, the correlative factor, and the number of employees for an SIC code, the amount of material disposed by a group of businesses in a city can be estimated. At this time, only limited preliminary composition data has been entered into the database for development, research, and demonstration purposes. As more generator specific samples are collected by local governments in California, they will be added and over time the data base will become more accurate and representative of the wide variety of businesses and jurisdictions in the state.

Limitations of the Database. Although the waste characterization database shows potential to be a very useful tool for solid waste planning, it has several limitations. The database needs a statistically representative number of generator samples in each subpopulation which requires expensive, detailed field studies. There can be significant variability in the composition and correlative factors for businesses within each subpopulation. As more generator samples are completed, subpopulations can be further split into more homogenous groupings to reduce variation within each subpopulation. The composition and correlative factor for each subpopulation is a state average and may not reflect the unique situation of each individual jurisdiction or region. As more reference data is developed, it may be possible to have region-specific reference compositions and correlative factors. The business databases available are updated only twice a year. There can be a significant number of changes between the updates, which generate inaccuracies in the database. The database will require regular maintenance and updating to reflect not only changes in the number and type of businesses, but also changes in how businesses and industries generate and dispose of wastes.

The basic format and structure of the database has been designed for maximum flexibility, and it could easily be expanded for use by other states and at the national level. To add an additional region or state, the business information for each additional state could be purchased from commercial vendors and added to the existing database. For waste composition data and correlative factors, reference samples would have to be taken from generators located in each of the states regions. Research would have to be conducted to identify the unique regional factors that impact waste composition and quantity.

Quantitative Field Sampling

This method consists of the physical separation, sorting, and weighing (or visual estimates) of solid waste from various waste hauling vehicles. The American Society for Testing Materials (ASTM) has described physical sorting in standard test method D 5231-92. At landfills or transfer stations, samples are taken from collection vehicles containing loads from several businesses and/or residences which have been mixed or compacted. This is non-source-specific sampling since the exact generation source is not known. A sample of approximately 200 pounds is selected randomly from the vehicle load to be characterized, either by randomly selecting a cell from a grid placed on the load, or by mixing (coning) the entire load and taking a random quarter (coning and quartering is repeated until a workable sample size is obtained). Care must be taken to ensure that the load is actually from the desired jurisdiction and/or sector to be characterized.

The quantitative field sampling method at landfills has been the predominant method that has been utilized by jurisdictions and solid waste consultants in California for characterizing waste disposal. The design of the characterization or sampling methodology and the level of detail for the waste characterization effort is primarily dependent upon the anticipated use of the data. Landfill studies can be designed to collect source-specific data by designing specialized collection routes or sampling from existing specialized routes.

Generator Based Sampling

This method consists of the physical separation and sorting and weighing, or visual estimation of solid waste directly disposed by the generator into specific material types. No standard method for generator sampling exists at this time. Samples have not been mixed or compacted with waste from other generators. Information must be gathered on the generators to be sampled.

Advantages to the generator sampling method include:

- Most accurate method for characterization of waste as disposed by generators;
- Data is more specific and flexible than landfill data to plan or evaluate targeted diversion programs and provide basis for technical assistance;
- Jurisdiction and sector of origin is easily identified;

- Less error introduced by cross contamination of waste from other generators and material types.

Disadvantages include:

- Requires high level of cooperation from generators and/or haulers;
- Resource-intensive and expensive method;
- Less accurate method of characterizing actual waste disposed if diversion occurs between the generator site and the disposal site.

Comparable or Existing Data

The comparable jurisdiction methodology is one by which a jurisdiction analyzes solid waste disposed in the jurisdiction by using existing solid waste composition data from another comparable jurisdiction or multiple jurisdictions. The jurisdiction(s) from which the existing data is taken must be comparable in meaningful aspects such as population, income level, and number and types of businesses for the comparison to provide fairly accurate data. Studies from numerous jurisdictions may be needed to get the most comparable data for each sector waste source. At this time, many field studies exist making the pool of information from which jurisdictions can choose comparable data much greater than in the past. The State of California currently specifies comparability criteria in regulation. That criteria includes population, residential tons disposed, number of dwelling units, commercial tons disposed, and number of commercial units.

Advantages of comparable data include the following:

- Low input of resources;
- No sampling required;
- Method is repeatable.

Disadvantages include:

- Data quality and accuracy from previous studies may be limited or outdated;
- Finding a truly comparable jurisdiction may be difficult;
- Data manipulation required;
- Differences in diversion programs, fee structures and local policies could effect applicability of data from another jurisdiction.

Combination Method

A combination of methods may be selected which provides the best overall data. For example, landfill sampling could be used to characterize the residential sector, generator sampling could be used for the commercial sector, and comparable data for the industrial sector, to develop a characterization for the entire jurisdiction.

Advantages of a combination approach include:

- Provides the most flexibility for jurisdictions;
- Potentially the most accurate method;
- Provides the most mechanisms for cross checking.

Disadvantages include:

- Potentially the most complicated;
- Overall statistical analysis is complicated.

SAMPLE RESULTS

Quantitative Landfill-based Sampling

In 1991, the Kern County Waste Management Department performed a waste characterization study in which quantitative field sampling was used at the landfill. Considering the types of decisions that would be made on the information provided from the study, it was determined early in the planning process that results should be statistically representable - California law only required "representable studies". Many studies done by jurisdictions in California were not statistically representable. For Kern County's study, the number of statistically representative samples was determined using Klee and Carruth's method for determining the number of samples required for estimating composition to a required level of precision. Kern County's study characterized approximately 1,700 two hundred pound samples representing over one million tons of solid waste. Sampling occurred over two seasons determined to be representative of the County's yearly climate conditions, winter and summer. Other conditions of the study included:

- 38 material categories;
- separation of waste into four sectors (residential, commercial, industrial, and agricultural);
- characterization at 14 landfills;
- characterization statistically representative for twelve individual jurisdictions.

Table 1 illustrates the composition of the waste stream for the residential, commercial, industrial and agricultural sectors for the Unincorporated County jurisdiction.

Table 1

1991 UNINCORPORATED KERN COUNTY WASTE CHARACTERIZATION STUDY

MATERIAL TYPE	Residential Sector (% disposed)	Commercial Sector (% disposed)	Industrial Sector (% disposed)	Agricultural Sector (% disposed)	Overall Total (% disposed)
Paper	19.29	21.34	4.38	9.15	15.27
Cardboard	4.64	9.61	2.87	4.84	5.57
Mixed Paper	3.13	1.74	0.18	0.63	1.80
Newspaper	4.29	1.93	0.16	0.20	2.30
High Grade	0.47	2.19	0.45	1.08	0.98
Other Paper	6.75	5.87	0.74	2.40	4.62
Plastic	6.71	6.07	1.40	2.61	4.87
PETE	0.23	0.11	0.00	0.00	0.13
HDPE	0.80	0.49	0.06	0.11	0.47
Polystyrene	0.45	0.62	0.03	0.05	0.37
Film	1.67	1.57	0.53	1.87	1.29
Diapers	1.80	0.60	0.01	0.02	0.89
Other	1.76	2.68	0.78	0.57	1.72
Metal	6.59	7.53	3.81	4.43	6.00
Aluminum Cans	0.22	0.21	0.01	0.03	0.15
Bi-metal Cans	0.02	0.04	0.00	0.00	0.02
Ferrous	4.90	5.96	3.66	4.09	4.75
Non-ferrous	0.34	0.54	0.11	0.31	0.33
White Goods	1.11	1.05	0.03	0.00	0.75
Glass	2.48	2.02	1.06	0.19	1.89
CA Redemption	0.95	0.63	0.01	0.07	0.57
Recyclable	1.42	0.79	0.02	0.04	0.79
Non-Recyclable	0.11	0.60	0.93	0.08	0.50
Refillable	0.00	0.00	0.10	0.00	0.03
Organic	55.90	48.75	22.97	78.29	44.06
Yard/Green	33.94	15.91	5.66	37.21	20.10
Food	7.03	4.69	0.67	6.66	12.52
Rubber	0.46	6.40	0.33	12.21	4.41
Wood	9.11	13.34	16.01	15.95	1.47
Agricultural	0.00	4.85	0.00	3.31	0.37
Manure	0.23	0.91	0.00	1.36	2.30
Textiles	4.10	1.61	0.20	0.64	2.14
Other	1.04	1.04	0.10	0.93	0.75
Inorganic	8.17	13.90	66.33	5.31	27.44
Inerts Solids	5.95	12.80	62.37	5.31	25.95
Aseptic	0.01	0.01	0.00	0.00	0.01
Other	2.21	1.09	0.96	0.00	1.48
Household Haz.	0.60	0.41	0.05	0.01	0.37
Special Waste	0.26	0.00	0.01	0.00	0.10
Ash	0.25	0.00	0.00	0.00	0.10
Sewage Sludge	0.00	0.00	0.00	0.00	0.00
Industrial Sludge	0.00	0.00	0.00	0.00	0.00
Asbestos	0.00	0.00	0.01	0.00	0.00
Auto Shredder	0.00	0.00	0.00	0.00	0.00
Auto Bodies	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00

This is the typical format of data as reported by most California jurisdictions within their 1990/91 studies. However, material type definitions and sorting protocols varied tremendously among studies.

CONCLUSIONS

A waste characterization study can provide people with useful information by which decisions can be made. The methods by which information is gathered can vary tremendously for one reason or another. But it is clear that if information is to be used on a regional or statewide basis, there is a need for a minimum level of consistency in the way characterization data is gathered and, more importantly, how materials are defined.

Economics have not been discussed in this paper; however, that is not to say that the cost to perform waste characterization studies has not been considered in the development of California's Uniform System. Ultimately, the regulatory requirements will, in one way or another, affect the cost of performing a study; however, flexibility is expected to be provided to jurisdictions in developing the degree and scope of study to be conducted and the method by which data will be gathered.

The State of California has begun to cast a foundation by which all characterization studies would be performed. At the same time, all California jurisdictions expect any such regulated system to provide the flexibility necessary to acquire meaningful data specific to the needs of local decision makers. The development of a Uniform Waste Characterization program for California may provide decision makers with better information by which to make decision; however, there is no guarantee that the decisions to be made will be easier to make, nor is there a guarantee that these decisions will be better decisions.

REFERENCES

[1] California Integrated Waste Management Board, Characterization and Analysis Branch; Workshop Reports; 1994 and 1995.

[2] County of Kern, Waste Management Department; Unincorporated Kern County Source Reduction & Recycling Element; 1994

[3] ASCE Journel, Volume 96, Sample Weights in Solid Waste Composition Studies; Albert J. Klee and Dennis Carruth, pp. 945-954, 8/70

[4] BioCycle; April, May 1995; pp. 54-63, 30-37.