SIC CODING AND SITE CHEMISTRY

STANDARD INDUSTRIAL CLASSIFICATION DATA

Standard Industrial Classification (SIC) data provides valuable insights into the chemical history of a given TRI or CRI site. This spill or exposure history may be associated with a chemical profile or signature which depicts the types and relative amounts or percentages of each chemical group that is produced by a set of busineses. In some cases, well-defined chemical profiles exist for a single SIC, enabling researchers to develop models for past uses for plots of land with similar profiles. Perhaps one of the more important uses for these signatures is relates to insights they provide us regarding a high risk site with an undocumented history.

This use of SIC and chemical profiling is not true for all sites. For this reason, use of SIC in analyzing environmental chemistry has its limits. In some cases, a given SIC has a complex signature which overlaps with other types of regions bearing different SIC values. However, such reasoning does not prevent the usefulness of chemical profiling CRI sites when analyzing the given chemical data. The more chemically complex such a site is, the more likely this may be or will become carcinogenic. With this in mind, it can be argued that SIC-defined chemical signatures serve not only as tools for analysis, but also as an possible indicator of identifier for predicting, verifying, or refuting possible causes for clusters of cancer cases around specific CRI sites.

SIC and Chemistry.

As demonstrated by this research, the relationship between SICs and chemical profiles is not steadfast. In its original form, SIC data rarely predicts the actual chemistry of a given CRI site. For this reason, SIC re-classification has to be employed to group together similar sites with similar chemical profiles in order to produce a certain amount of homogeneity in the resulting chemical profiles that are produced. In this analysis of Oregon companies, a method of reclassifying CRI sites based on SIC and chemical data was developed. The basis for this re-classification method is detailed in **TABLE 6-1**.

Whereas in some cases the chemical profile of a given SIC is quite predictable, numerous cases exist for which predictability is more difficult. In cases where there are limited numbers of sites with similar SICs, this method of analysis losing its statistical value. This in fact is the chief limiting factor in this analysis of Oregon sites. Some of the reclassified SIC groups bear relatively few sites, for example tanning and creosote industries for which just a few datasets exist in the Oregon CRI dataset. For this reason, chemical profiles are most useful when combined with SIC data based on many sites. The re-classification method serves to increase the number of sites that can be chemically compared. Therefore, to accurately employ SIC data in this sort of site analysis, a reclassification has to be used, assigning related SICs to similar groups in order to compare one set of SIC-defined sites and their chemistry with other SIC-defined sites.

INSERT TABLE 6-1 (next several pages)

Gasoline stations provide one of the better examples for analyzing reclassified SIC-derived chemical profiles. These sites are most likely to be inspected for petroleum product spills, a feature numerous other CRI sites possess as well. In Oregon, nearly 60 gasoline stations are listed in the CRI registry. If we compare these gasoline stations with sites where chemical spills, similarities exist between the two (**TABLE 6-2**). In this case, it is not the business or the SIC that defined the chemical signature, but rather the spill itself. In the end, since the basic petroleum product is the shared feature of these two types of sites, the SIC for the business or industry residing on that site is not the sole identifier for the final chemical profile.

Another industry, the early 20th century tanning industry, is currently linked to Chromium deposits, a common form of metal contamination noted for other chemical industries as well. This contrasts with our expectations for nineteenth century tanning industries, which utilized of bark-derived phenolics in combination with common metals like Iron. Still, any review of such sites provides us with insights into the history of that site; older tanning sites should have a chemical profile distinctly different from the more modern Chromium-based industries. Moreover, long-lived companies may present with the presence of both of these types of chemicals.

A simpler example of the use of CRI-derived chemical profiles involves dry cleaning facilities. These sites are typically analyzed for the presence of tri- and tetrahalogenic compounds. It is not unusual however to find such sites bearing more generic industrial chemical contaminants like petroleum products, paint-related substances, and certain other waste-related chemicals.

The most important application of chemical profiling is defining health-related risks for a given CRI site. These chemical profiles may be related compared with profiles that exist for other sites with identical SIC code or SIC reclassification codes. Such an approach can help define cancer risk differences that exist between otherwise similar business and industrial settings. Tests results not consistent with known history of the use of that land based on SIC should raise suspicion concerning such issues as unreported spills or illegal dumping.

In sum, SIC codes are quite useful in analyzing Oregon CRI sites. This use of SIC is improved greatly by a reclassification process, by which chemical profiles of different site can be compared and contrasted to produce profile applicable to later research of other SIC sites. This reclassification of SIC enables more concise grouping of chemically similar businesses. These similarities, termed “signatures” for this study, demonstrate uniqueness for specific SIC-defined, reclassified groupings.

Table 6-2

SIC Codes. In theory, businesses with distinctly different SICs (the 1000, 2000, 3000, 4000, 5000, 6000, and 7000 series) can have nearly identical chemical waste production. Automotive industries, facilities responsible for basic automobile manufacturing, automotive maintenance (SIC 7500 series), automotive parts dispersal (SIC 4449 and 7500 series), automobile sales (mostly SIC 5511), automotive parts sales (SIC 4449), and automotive part recycling (SIC 5015, 5075, 5093, 5105, etc.) produce similar waste products and environmental contaminants, namely various metal, electric, paint and petroleum products. Likewise, metals industries differ little in waste production, be they metal foundries (SIC 3300 and 3400 series), metal product manufacturers (SIC 3500 series), and metal parts manufacturers (some SIC 3500 series). However, these same industries vary greatly with waste products and contaminants produced and released by mineral ore mining industries (SIC 1000 series), electronics manufacturing industries (SIC 3600 series and some SIC 3300 series), and complex high technology transportation industries (i.e. airplane manufacturing SIC 3700 series and airport maintenance 4581, autobuses and trucking repair and production 4231 and 4225, railroad train car production/maintenance SIC 3714 and 3728, versus railroad yards--SIC 4011 and 4013). Each of these sets of similar industries can be differentiated from one another through their signatures.

Developing chemical signatures or profiles. To define the chemical signature for a CRI site, chemicals which appear in the reports have to be grouped in such a way that each group consists of chemically similar substances. This grouping does not imply identical toxicity or carcinogenicity, for even structurally and metabolically similar isomers do not possess identical levels of carcinogenicity. However, similarity may be assumed for different members of the same group. For example, carcinogenicity differs greatly between two very similar halogenated aromatic compounds—1,3,5-trimethylbenzene (highly carcinogenic) versus 1,2,4-trimethylbenzene (toxic, but not a noted carcinogen). Yet, it the environmental setting, the presence of one does not necessarily exclude the other. This is especially true for by-products of degradation. For this reason CERCLA includes Heptachlor, Heptachlor Epoxide, Heptachlorodibenzofuran, Heptachlorodibenzo-P-Dioxin and Hexachlorodibenzo-P-Dioxin on its High Priority listing of chemicals. In spite of the differences that exist in the toxicity for each of these related chemicals, grouping by chemical type enables us to define industry types and SIC related chemical profiles that have a greater likelihood of releasing toxic chemicals and carcinogens. Several classification methods were attempted to produce and demonstrate the value of reclassifying SIC in public health-related environmental chemical research.

The 250 chemicals listed in the Oregon EPA reports may be reclassified by chemical nature into as many as 34 classes or categories. Take for example, the listing of chemicals found at 24 sites of undeveloped land or property (**TABLE 6-3**).

TABLE 6-3

CHEMICALS REPORTED FOR VARIOUS UNDEVELOPED PROPERTIES (ALL SITES RECLASSIFIED AS SIC 8999)

24 sites

CLASS	nReports	nChems
Agritox	1	1
Aliphatic	1	1
Aromatic	8	3
Element	8	1
Halogenic Aliphatic	25	10
Halogenic Aromatic	6	3
Metal	52	8
Organic Metal	2	1
OTHER	3	3
PAH	28	14
PCBs	6	1
Petrol	18	5
Phthalate	3	3
Pyrene	3	2
	162	56

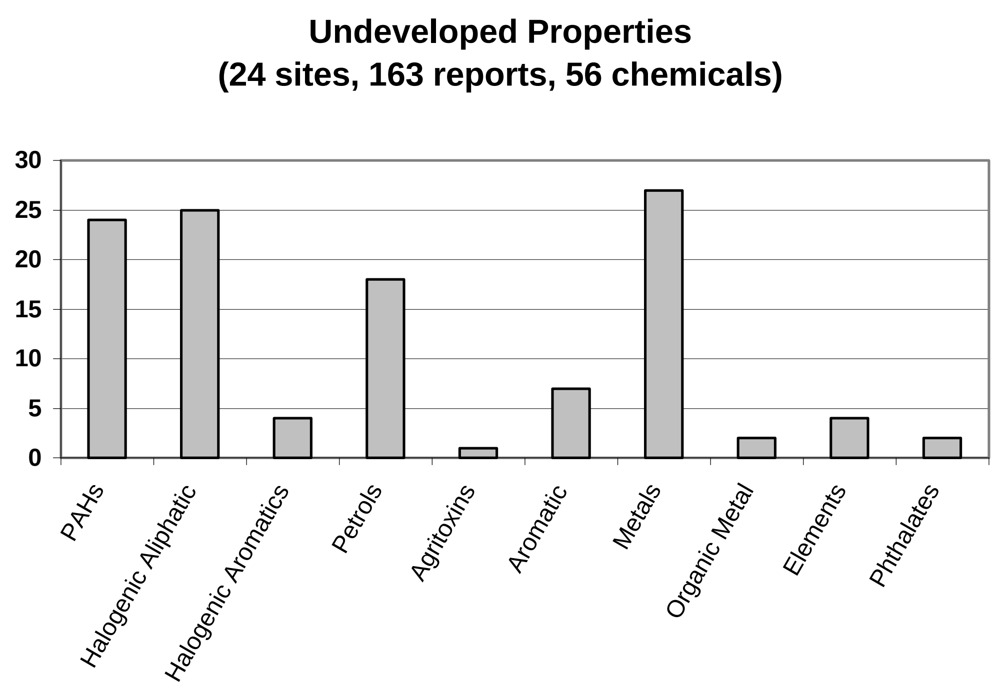
Based on this and similar reviews of 509 Oregon CRI sites, the following chemical groups were emphasized in developing a method to differentiate CRI site chemistry:

- Elemental, i.e.
- Metal, i.e. Fe, Cu
- Organic Metal, metals bound to an organic molecule, esp. Cr and Cu
- Aliphatic, i.e. MetOH, EtOH, Acetone
- Aromatic, i.e. Simple one-ring structures like Benzene and Phenol,
- Polycyclic Aromatic Hydrocarbons (PAHs), i.e. naphthalene, anthracene, fluoranthene
- Petroleum products, i.e. gasoline, kerosene, crude oil
- Halogenic Aliphatics, i.e. Carbon Tetrachloride
- Halogenic Aromatics, i.e. the trichlorobenzenes

Smaller classes less frequently reported by these sites were for the following chemical groups: uncommon Inorganic substances, “Paint chemicals”, “ionic” materials, neurotoxins, agritoxins (i.e. for domestic and agribusiness use), cyanide (industrial use), and Cresol (creosoting business). These are typically included under “Other” unless otherwise specified. Some of these scarcer chemicals tested for serve as indicators for particular sites, i.e. cresols and creosote for creosoting businesses.

A given SIC-defined TRI site will contain specific types of carcinogenic compounds. These are indicated in the following bar chart, in which the reclassification technique merged the information from 24 sites together, i.e.

FIGURE 6-1



A disadvantage to this approach is that this grouping does not differentiate chemicals within a single class by their levels of toxicity. Some groups contain compounds with greatly varying levels of toxicity and/or carcinogenicity. For PAHs, chemicals vary from the non-toxic chemicals like naphthalene to highly carcinogenic anthracene and fluoranthene derivatives. Even though simple SIC chemical signatures exist for dry cleaning facilities, producing primarily a number of different trichloro and tetrachloro compounds, some of these compounds are only questionably carcinogenic and others not at all carcinogenic. As mentioned earlier, another disadvantage of this approach to analyzing a CRI site is that presence of a compound does not imply human exposure or contact. Highly toxic sites may be located at reasonable distances from populated regions (i.e. illegal dumping sites and old mines) and not cause any exposure *per se*. Alternatively, a populated area situated next to a toxic site may still be protected from exposure due to clean up activities, chemical degradation, microbial chemical consumption activities, or lack of proximity.

Chemical Profiling

Two SIC-related features affect site chemistry. First, the type of SIC and business and human activities for a given site affect its chemical profile. Second, the age of the site impacts chemical profiles due to the changes in chemistry induced by the effect of time on chemicals in the form of deterioration or changes brought on by natural and manmade events.

Of the 350 chemicals possible in CRI sites, Oregon sites bore approximately 250. Thirty-four profiles were produced based on this chemical data using the SIC reclassification process defined in **TABLE 6-1** (pages 6-3 to 6-6). Twenty-four of these profiles are provided for review at the end of this section (**FIGURES 6-3** to **6-7**).

To produce "signatures" for reclassified CRI sites, Dry Cleaning businesses retained their original SIC value (SIC 7200), as did the Battery Storage/Recycling facilities (SIC 3690) and Paper Industries (SIC 2700 series) (**TABLES 6-4, 6-6, 6-8**). Groundwater Contamination Sites were reclassified to SIC 4941 due to a shared contamination feature not at all related to the type of business involved (**TABLE 6-5**). A review of the chemistry of businesses devoted to boat/ship maintenance and repair (**TABLE 6-7**) demonstrates the complexity of sites devoted to chemical-based work such as repairs and resurfacing, along with the most basic maintenance activity--refueling in the form of petroleum and, more historically, coal-derived products.

In the end, this method of analysis produced a total of 34 Reclassified Groupings, demonstrated by a series bar charts useful for illustrating these profiles of given groups or classes of sites (**TABLES 6-1** through **6-7**). These "fingerprints" provide a method for defining possible causality for toxins found at future sites of unknown economic history. Past creosote-producing sites for example may be suggested by the presence of PAHs, Metals, halogenic Aromatics, and Cresol (a chemical fairly unique to tanning industries which is not included in the bar chart) (**TABLE 6-9 and FIGURE 6-3**). Differences between sites of similar SIC, but greatly differing history may also be depicted (**FIGURES 6-3 to 6-7**).

In sum, this part of the project was meant to demonstrate a means for evaluating CRI sites based on SIC-derived chemical profiling. Missing from this analysis is an analysis of site chemistry focused on concentration in relation to time and age of site. Although significant, this type of analysis cannot be done for CRI sites in which poor quality chemical data was provided. Some site reports provide ranges for a given chemical. Others provide just a mean value, and still others a series of values measured by multiple tests. Still more troublesome the lack of such information for certain chemical types, for which there is a lack of standardized testing for providing this information (i.e. Petrols) (**FIGURE 6-8**).

Age and temporality

Advances in technology show the effect of impacting what types of chemicals are released by a particular type of site fitting within a specific SIC group. Facilities for which age was assessed are noted in TABLES and FIGURES. In brief, long-lived facilities include those devoted to energy production, tanning agent production, paint production and waste treatment (dump sites). Short-lived facilities are typically small businesses (esp. corner stores, dry cleaners, and gas stations) and high technology businesses (electronic device manufacturers).

Age is related to type of chemical exposure and length of exposure time for a given facility. Based on the CRI data, the age of the site could be assessed for nearly all sites. Of 540 original CRI datasets reviewed for this work, most could be assessed for age and maximum period of environmental release. Of these, forty percent (216) were in business for more than 30 years (**FIGURES 6-8, 6-9**, **6-10, TABLE 6-10**).

Older sites are effected by two things: 1) change in business type and related SIC code, and 2) change in business or industrial technology in use. Some sites bear multiple types of toxins due to the underlying changes in the technology of the business. One of the best examples of this change involves railroad locations and power generating/transmitting facilities. Older railways demonstrate their age by the presence of anthracite-derived polycyclic aromatic hydrocarbons and more recent diesel fuel generated spills. For similar technological reasons, much the same contaminants may be found on sites related to power-generating facilities, sites best known for their more recent chemical s--PCBs. Likewise, whereas old town dumps may be rich in paints and wood-treatment chemicals, recent legal and illegal dump sites are more apt to contain a variety high technology solvents and radioactive waste.

SUMMARY

The value to chemical profiling a site is that it provide researchers with the ability to define the complexity and toxicity for a given CRI site. These profiles may be used to define the potential carcinogenicity of a given site or region, and to relate it to other sites for a cross-comparisons, or to produce chemical profiles for a defined set of CRIs and SICs. In theory, a site that is highly toxic, carcinogenic, and in need of clean-up is more so when: 1) large amounts of a single chemical are present, 2) multiple chemicals of varying toxicity and carcinogenicity are present, and 3) these chemicals have been present for long periods of time. Whereas research often focuses on exposures to a single chemical, element, or form of energy as an risk factor for carcinogenesis, exposures to multiple chemicals at CRI sites has been difficult to quantify. This analysis of Oregon CRI sites attempts to define several ways to evaluate such sites, with hopes of applying this method to high risk site selection processes. In the final section of this work, such an attempt is made.

TABLE 6-4

CHEMICALS AT DRY CLEANING BUSINESSES IN OREGON
(ORIGINAL SIC CODE 7200; RECLASSIFICATION CODE 7200)

22 sites

Chemical	***N***	***Chemical Group/Class***
BUTYLBENZENE,n-	1	Aromatic
ETHYLBENZENE	1	Aromatic
ISOPROPYLTOLUENE,p-	1	Aromatic
PROPYLBENZENE,n-	1	Aromatic
TOLUENE	2	Aromatic
CHLOROFORM	1	Halogenic Aliphatic
DICHLOROETHANE,1,2-	1	Halogenic Aliphatic
DICHLOROETHYLENE,1,1-	1	Halogenic Aliphatic
DICHLOROETHYLENE,1,2-CIS-	13	Halogenic Aliphatic
DICHLOROETHYLENE,1,2-TRANS-	4	Halogenic Aliphatic
METHYL CHLORIDE	1	Halogenic Aliphatic
METHYLENE CHLORIDE	1	Halogenic Aliphatic
PERCHLOROETHYLENES	2	Halogenic Aliphatic
TETRACHLOROETHYLENE	43	Halogenic Aliphatic
TRICHLOROETHANE,1,1,1-	2	Halogenic Aliphatic
TRICHLOROETHANE,1,1,1-	2	Halogenic Aliphatic
TRICHLOROETHYLENE	19	Halogenic Aliphatic
VINYL CHLORIDE	5	Halogenic Aliphatic
DICHLOROBENZENE,1,4-	1	Halogenic Aromatic
TRIMETHYLBENZENEs	2	Halogenic Aromatic
XYLENEs	2	PAH
FUEL OIL	1	Petrol
PETROLEUM	1	Petrol
PETROLEUM HYDROCARBONS	1	Petrol
VOLATILE ORGANIC COMPOUNDS (VOC)	2	VOC

SUMMARY:

22 sites

Class	**nReports**	**nChems**
Aromatic	4	4
Halogenic Aliphatic	2	1
Halogenic Aromatic	95	14
PAH	2	1
Petrol	3	3
VOC	2	1
	108	24

TABLE 6-5

CHEMICALS AT GROUNDWATER CONTAMINATION CRI SITES
(ORIGINAL SIC CODES VARY BY BUSINESS; RECLASSIFICATION CODE 4941)

11 sites

CHEMICAL	***n***	***CLASS/GROUP***
DDE,p,p'-	1	Agritox
METHYL-tert-BUTYL ETHER	1	Aliphatic
TOLUENE	2	Aromatic
BENZENE	1	Aromatic
ARSENIC	1	Element
MANGANESE	1	Element
TRICHLOROETHYLENE	14	Halogenic Aliphatic
TETRACHLOROETHYLENE	11	Halogenic Aliphatic
DICHLOROETHYLENE,1,2-CIS-	8	Halogenic Aliphatic
TRICHLOROETHANE,1,1,1-	8	Halogenic Aliphatic
DICHLOROETHYLENE,1,1-	4	Halogenic Aliphatic
DICHLOROETHYLENE,1,2-TRANS-	4	Halogenic Aliphatic
DICHLOROETHANE,1,1-	3	Halogenic Aliphatic
VINYL CHLORIDE	3	Halogenic Aliphatic
CHLOROFORM	1	Halogenic Aliphatic
DICHLOROETHYLENE,1,2-	1	Halogenic Aliphatic
METHYLENE CHLORIDE	1	Halogenic Aliphatic
ALUMINUM	1	Metal
ANTIMONY	1	Metal
CADMIUM	1	Metal
CHROMIUM	1	Metal
COBALT	1	Metal
COPPER	1	Metal
IRON	1	Metal
LEAD	1	Metal
MERCURY	1	Metal
NICKEL	1	Metal
SELENIUM	1	Metal
TITANIUM	1	Metal
ZINC	1	Metal
POLYAROMATIC HYDROCARBONS (PAH)	1	PAH
PCBs	1	PCBs
	80	

SUMMARY (FOR TABLE ON PREVIOUS PAGE)

11 sites

Class	N chemicals	N reports
Halogenic Aliphatic	11	58
Aromatic	2	2
Metal	13	13
Element	2	2
Agritox	1	1
Aliphatic	1	1
Halogenic Aromatic	0	0
PAH	1	1
PCBs	1	1
	32	79

TABLE 6-6

CHEMICALS AT BATTERY STORAGE/RECYCLING SITES
(ORIGINAL SIC CODES ca 3690; RECLASSIFICATION CODE 3690)

5 Sites

CHEMICAL	N	GROUP
ARSENIC	2	Element
CADMIUM	1	Metal
CHROMIUM	3	Metal
D001 ACIDIC HAZARDOUS WASTE	1	Other
DIESEL - FUEL OIL	1	Petrol
LEAD	14	Metal
PETROLEUM	1	Petrol
SULFURIC ACID	5	Other
ZINC	3	Metal
	31	

SUMMARY:

5 sites

	BATT3690 nChem	BATT3690 nReport
Elements	2	3
Metals	3	20
Petrol	2	2
Other	2	6
SUM	9	31

TABLE 6-7

CHEMICALS AT SHIP BUILDING & REPAIR SITES
(ORIGINAL SIC CODES ca 3730; RECLASSIFICATION CODE 3730)

16 sites

CHEMICAL	N	CLASS/GROUP
COPPER	13	Metal
CHROMIUM	11	Metal
TRIBUTYLTIN	11	Metal, Organic
LEAD	9	Metal
ZINC	8	Metal
PCBs	8	PCBs
ARSENIC	7	Element
NICKEL	7	Metal
MERCURY	4	Metal
FLUORANTHENE	3	PAH
OIL OR FUEL RELATED COMPOUNDS	3	Petrol
ANTIMONY	2	Metal
No Data	2	Other
BENZO(a)ANTHRACENE	2	PAH
BENZO(a)PYRENE	2	PAH
BENZO(b)FLUORANTHENE	2	PAH
CHRYSENE	2	PAH
INDENO(1,2,3-cd)PYRENE	2	PAH
PHENANTHRENE	2	PAH
PYRENE	2	PAH
PETROLEUM HYDROCARBONS	2	Petrol
DDD,p,p'-	1	Agritox
DDT,p,p'-	1	Agritox
DIELDRIN	1	Agritox
CADMIUM	1	Metal
METALS	1	Metal
ACENAPHTHENE	1	PAH
ANTHRACENE	1	PAH
BENZO(ghi)PERYLENE	1	PAH
DIBENZO(a,h)ANTHRACENE	1	PAH
DIBENZOFURAN	1	PAH
FLUORENE	1	PAH
NAPHTHALENE	1	PAH
GASOLINE	1	Petrol

SUMMARY (for previous Table):

16 Sites

	MARI3730	MARI3730
CHEM	**reports**	**types**
Agritox	3	3
Element	1	1
Metal	56	9
Metal, Organic	11	1
Other	2	1
PAH	25	15
Petrol	4	2
PCBs	8	1
	110	33

TABLE 6-8

CHEMICALS AT PAPER INDUSTRY SITES
(ORIGINAL SIC CODES var 2700s; RECLASSIFICATION CODE 2700)

3 sites

CHEMICAL	N	CLASS
DICHLOROETHYLENE,1,1-	1	Aliphatic Halogenic
DICHLOROETHYLENE,1,2-CIS-	2	Aliphatic Halogenic
DICHLOROETHYLENE,1,2-TRANS-	1	Aliphatic Halogenic
TETRACHLOROETHYLENE	5	Aliphatic Halogenic
TRICHLOROETHYLENE	5	Aliphatic Halogenic
TRICHLOROMONOFLUOROMETHANE	1	Aliphatic Halogenic
BENZENE	1	Aromatic
ETHYLBENZENE	1	Aromatic
TOLUENE	3	Aromatic
XYLENEs	1	PAH

SUMMARY

3 sites

	PAP2700	PAP2700
Chemical	**nChem**	**nReports**
Aromatic	3	5
Aliphatic Halogen	6	15
PAH	1	1
SUM	10	21

TABLE 6-9

CHEMICALS AT CREOSOTING SITES
(ORIGINAL SIC CODES 2491; RECLASSIFICATION CODE 2491)

12 sites

CLASS	N	PCT
PAH	19	50.00
Metal	9	23.68
Halogenic Aromatic	3	7.89
Aromatic	1	2.63
Cresols	1	2.63
Element	1	2.63
Halogenic Aliphatic	1	2.63
OTHER	1	2.63
Petrol	1	2.63
VOC	1	2.63
SUM	38	100.00

FIGURE 6-2

Creosoting Industry
(12 sites, 145 reports, 38 chemicals)

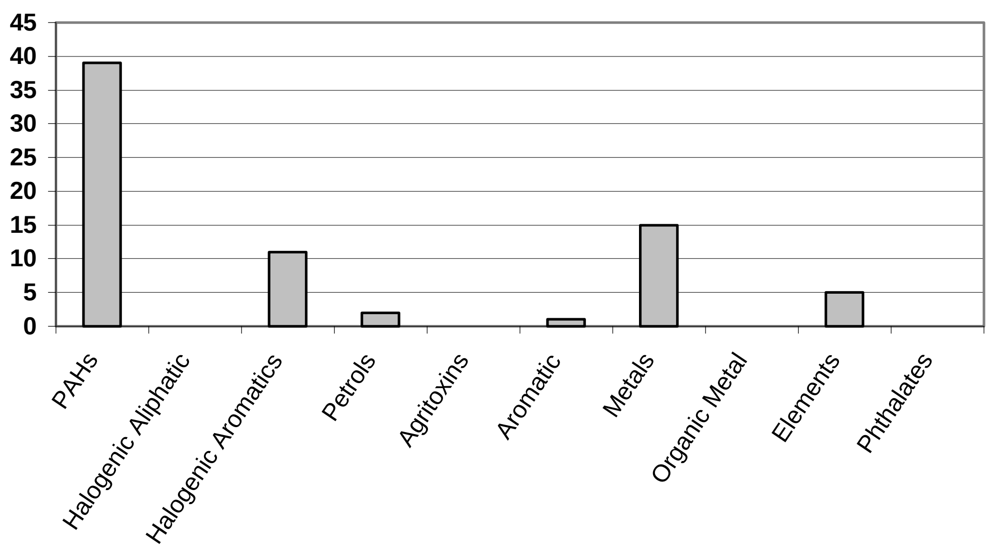
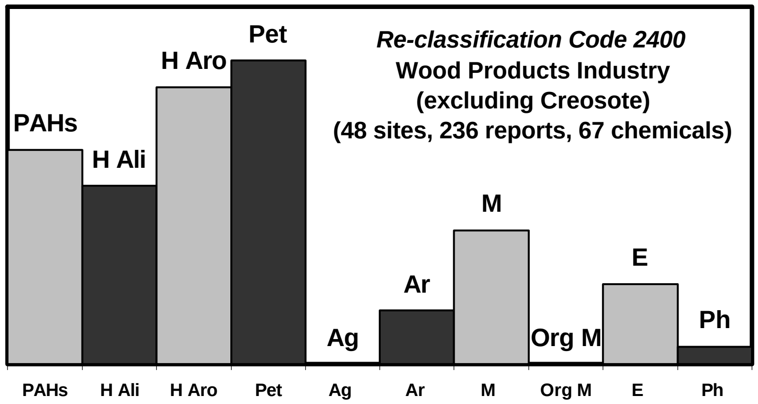
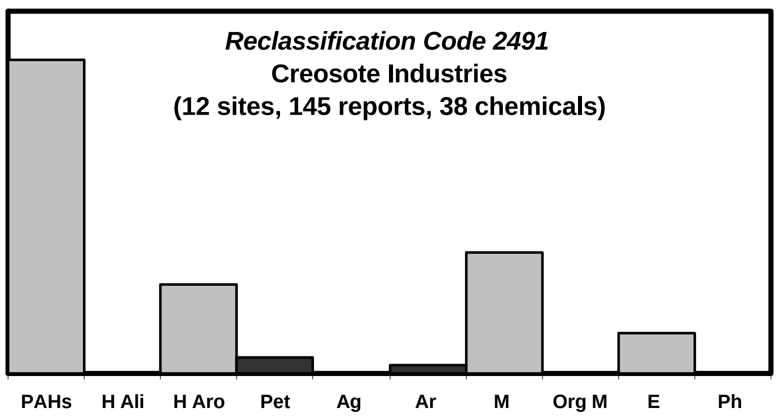


FIGURE 6-3

CHEMICAL PROFILES FOR CRI SITES PRODUCED BY FORESTRY PRODUCTS INDUSTRIES IN OREGON, CA. 1890 TO 1995.





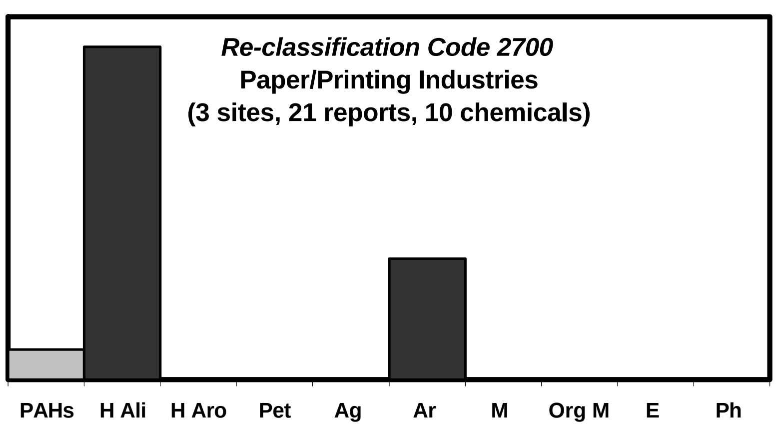


FIGURE 6-4 INSERT

FIGURE 6-5

CHEMICAL PROFILES FOR AUTOMOBILE RELATED CRI SITES

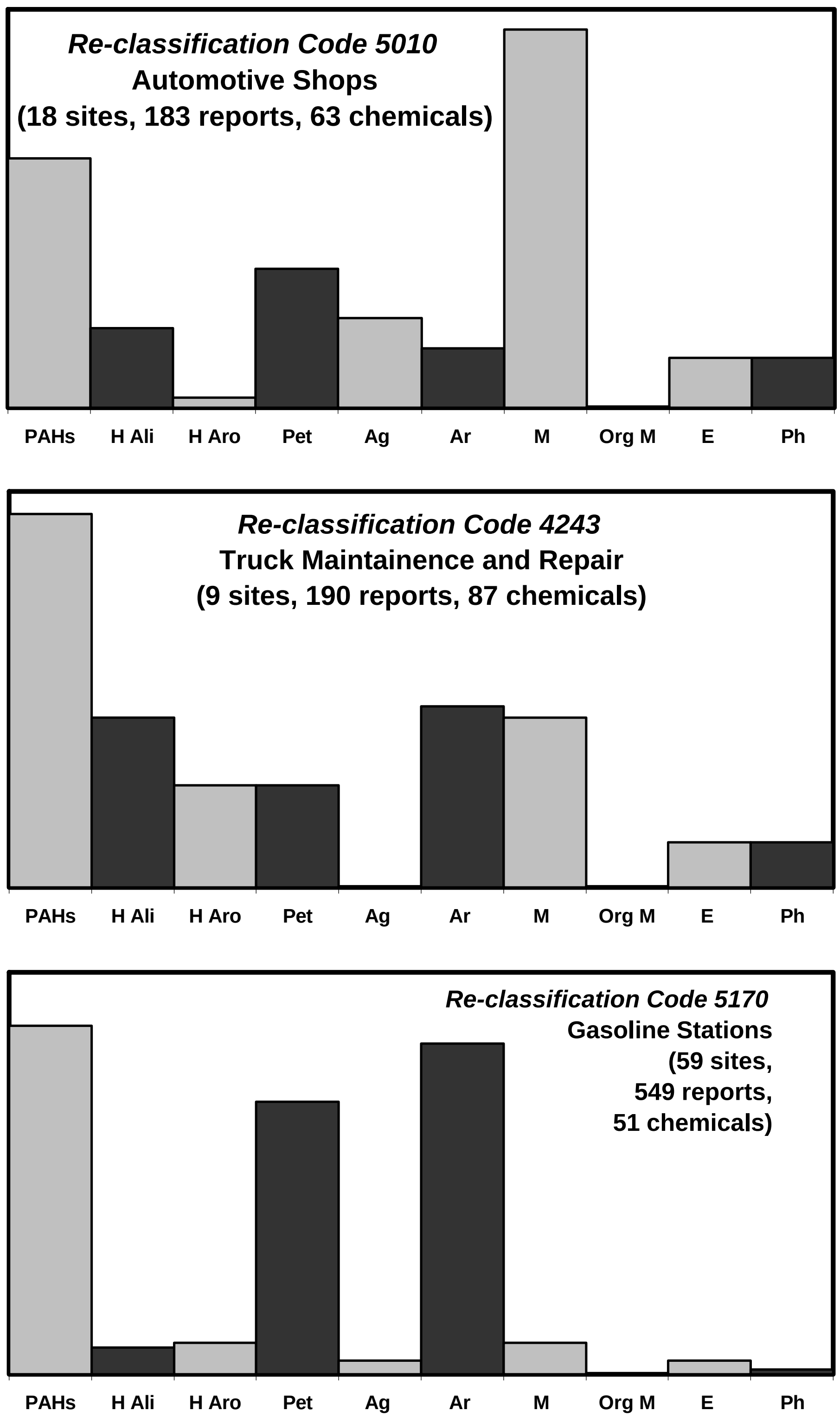
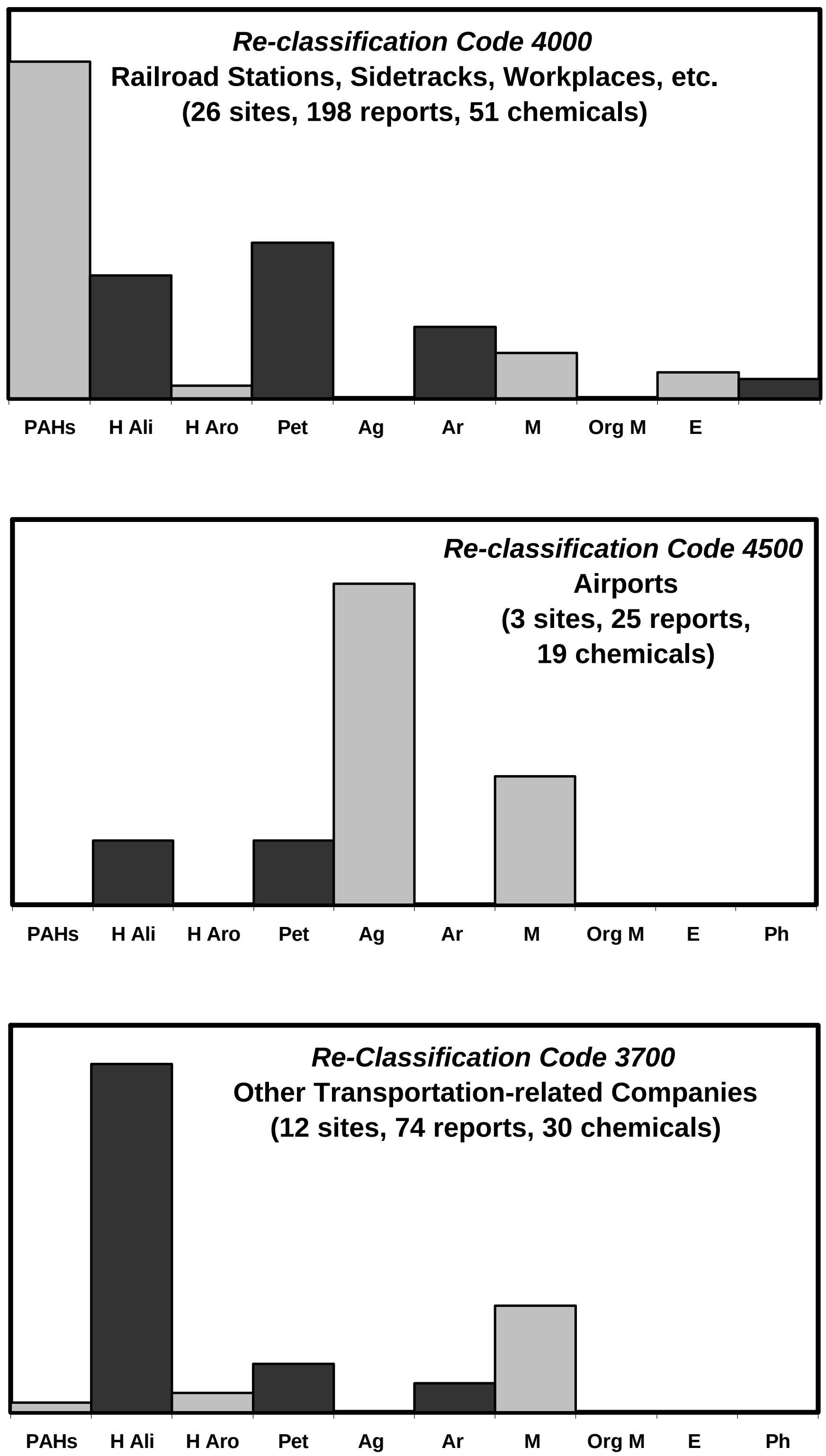


FIGURE 6-6

CHEMICAL PROFILES FOR SITES RELATED TO PUBLIC TRANSPORTATION



FIGURES 6-7 through 6-10 INSERTS

TABLE 6-10 INSERT (3 pages)