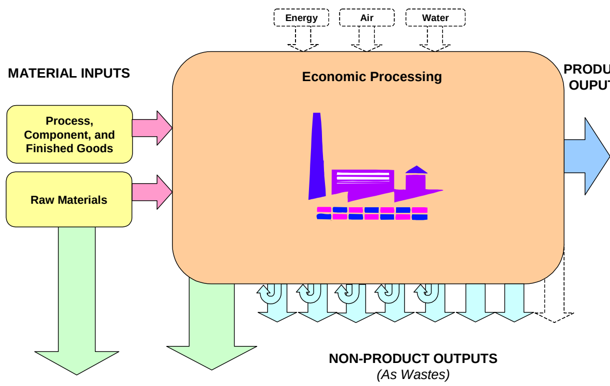
Beyond Waste Consultant Team Issue Paper #1
June 2, 2003

Waste & Material Flows in Washington

A Conceptual Model and Characterization of Waste and Material Flows



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Executive Summary

> **Ecology's Beyond Waste vision:**
>
> *"We can transition to a society that views wastes as inefficient uses of resources and believes that most wastes can be eliminated. Eliminating wastes will contribute to social, economic, and environmental vitality."*

The Washington State Department of Ecology is charged with protecting, preserving and enhancing Washington's environment; and promoting the wise management of air, land and water for the benefit of current and future generations. To support this mission, Ecology's Solid Waste and Financial Assistance Program and the Hazardous Waste and Toxics Reduction Program have together launched the Beyond Waste Project. This project is intended to guide Washington in a new direction, from containing and managing wastes toward creating systems where waste does not exist – systems that prevent waste in the first place, view materials as valuable resources, and eliminate toxics.

The consultants for this project, Cascadia Consulting Group and Ross and Associates, have prepared a series of issue papers to report on their research and recommendations. The primary purpose of this first paper is to present an overview of the waste and material flows in Washington State. This overview will set the stage for the consultant's analysis of waste elimination strategies and tracking system improvements in Consultant Team Issue Papers #2 - #7.

The consultants concluded that a thorough review of waste should also consider the life cycle of products and materials before they become waste. In moving forward with the Beyond Waste vision, it will be important to consider not only the quantities and types of waste but also the input of materials into the economy and the processes that transform them into the products and structures used in our daily lives. Accordingly, the consultant designed the *materials flow framework*, which was based on a recent model developed by the World Resources Institute, to help:

- Identify particularly large or toxic material flows;
- Determine gaps in Ecology's current tracking systems; and
- Design Beyond Waste strategies to reduce and eliminate wastes.

In this first issue paper, the materials flow framework is used to characterize each of the major material and waste flows in Washington State. Each of these assessments includes descriptions of the material or waste flow's sources, quantities, significance, and existing tracking systems. This information forms the basis for the creation of Beyond Waste initiatives in Consultant Team Issue Paper #2 – *Achieving the Beyond Waste Vision* and detailed strategy development in Issue Papers #3 - #5.

In the course of this research, the consultants estimated that the solid and hazardous wastes tracked by Ecology represent only a portion of the waste and material outputs of the state. In particular,

- Nearly 100 million tons of greenhouse gasses are emitted each year as a by-product of the burning of fossil fuels;
- Approximately 80 million tons of earth are displaced each year due to construction;
- Over 70 million tons of soil erosion, crop residues, forestry slash, and mining wastes occur each year; and

- Approximately 20 million tons of animal manures, dredged material, pesticides, and other materials are generated each year; whereas
- The solid, hazardous, moderate risk, and recycled wastes tracked by Ecology each year amount to only about 12 million tons.

In other words, the solid and hazardous wastes tracked by Ecology represent less than 5% of the total annual waste and material flows in Washington. Some of these other wastes and materials should perhaps be tracked by Ecology. To this end, Consultant Team Issue Paper #7 – *Improving Waste and Materials Tracking in Washington,* presents an assessment of gaps in Ecology's tracking systems. Issue Paper #7 also presents recommended improvements – and an entirely new approach – to waste and materials tracking in Washington.

The next issue paper, Consultant Team Issue Paper #2 – *Achieving the Beyond Waste Vision*, builds on this materials flow framework to develop highly promising initiatives by considering what wastes are generated by which economic actor sectors, what trends are likely to affect waste generation, and what tools are available to influence the generation of waste in Washington.

1. Introduction

Ecology's Beyond Waste Vision

"We can transition to a society that views wastes as inefficient uses of resources and believes that most wastes can be eliminated. Eliminating wastes will contribute to environmental, economic and social vitality."

This paper is the first of seven issue papers prepared by the consultant as part of the Beyond Waste project. The primary purpose of this paper is to present an overview of the waste and material flows in Washington State to set the stage for the consultant's analysis of tracking system improvements and waste elimination strategies. It will include a characterization of each major waste flow in the state, including solid and hazardous wastes. Each characterization will include descriptions of the material or waste flow's sources, quantities, significance, and existing tracking systems.[1]

In the course of compiling this information, the consultant also developed a conceptual model, based on the flow of material through Washington's economy, to help organize and describe what wastes are generated, and by what sectors of the economy. The consultants believe that a thorough review of waste should also consider the life cycle of products and materials before they become waste. Consequently, in moving forward with the Beyond Waste vision, it will be important to consider not only the quantities and types of waste but also the input of materials into the economy and the processes that transform them into the products and structures used in our daily lives. Consequently, the consultant designed the *materials flow framework* , which was based on a recent model developed by the World Resources Institute, to help:

- **Identify particularly large or toxic material flows —** One way to use the materials flow framework is to thoroughly consider the types of materials flowing through the economy, their origins, and the other materials or processes used in their production, transportation, or use. This type of research and thinking has helped the consultant identify particularly large and/or toxic material flows. In other words, instead of starting with what is already understood or measured, the materials flow framework can help describe the universe of wastes and materials in Washington, and who might handle, use, or generate them.

- **Determine gaps in Ecology's current tracking systems —** The materials flow framework provides the opportunity to consider which flows are currently tracked by Ecology (or other agencies) and which are presently untracked.

- **Design Beyond Waste strategies to reduce and eliminate wastes**.[2] **—** By considering combinations of specific materials or goods with the activities and economic sectors that generated them, it will be possible to develop effective strategies to reduce and eliminate wastes. This type of analysis contributed to the strategies presented in Consultant Team Issue Papers 3, 4, and 5.

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[1] The Consultant Team's Issue Paper #7, *Improving Tracking of Material Flows and Waste*, recommends improvements to Ecology's current waste tracking system and a new conceptual approach to measuring the wastes and materials that are present in Washington's economy.

[2] In presenting this framework, the consultant does not assume that Ecology will choose to measure or track all of the flows presented. Possible future waste tracking approaches, including recommendations, are described in Consultant Team Issue Paper #2. The use of this materials flow framework is independent of the options presented or recommended in Consultant Team Issue Paper #2.

2. Materials Flow – A Conceptual Model

All solid and hazardous wastes are composed of combinations of raw materials. Raw materials can be:

- Extracted or harvested;
- Transformed into components;
- Assembled into products;
- Distributed to users (whether business, industry, or residents);
- Recycled into other products and re-distributed; and, eventually
- Disposed.

This transformation of materials into products, their distribution, use and ultimate disposition can generate waste at each step in the process. These wastes can be seen as “an inefficient use of resources”, particularly since they may contain valuable materials.

MATERIALS FLOW FRAMEWORK

Figure 1 depicts the flow of materials through Washington’s economy. This *materials flow framework* is based on a model developed by the World Resources Institute (WRI)[3] for use in its recent study of material flows in the United States and four other countries. Similar models are in use by the United States Environmental Protection Agency (EPA)[4] and the United States Geological Survey (USGS).[5]

The model focuses on Washington’s human economy and its interface with the natural environment, following the convention adopted from WRI. Using this approach:

- Materials enter the economy when they are purchased; and
- Materials exit the economy when they are no longer available to play a role in the economy.

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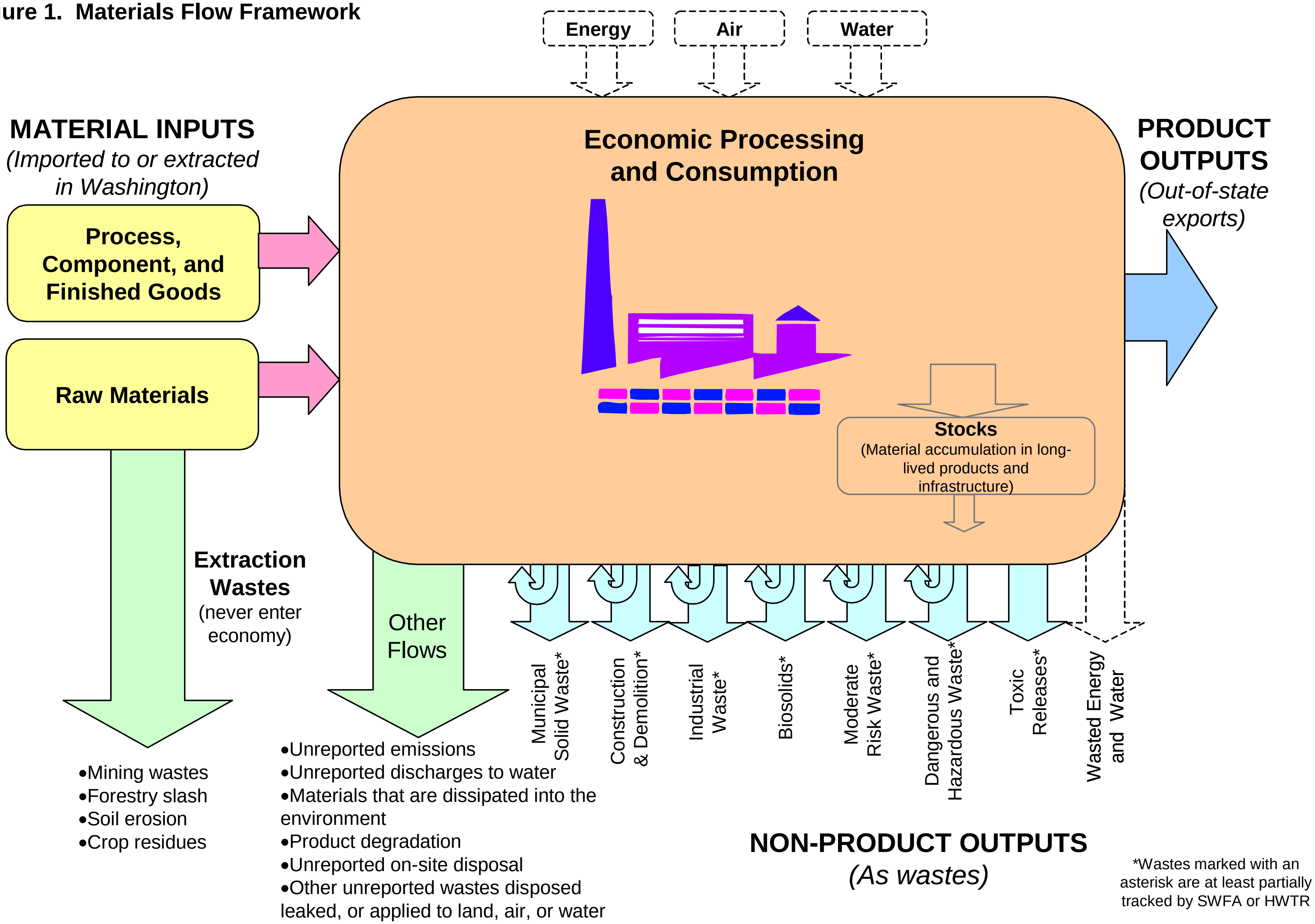
[3] The World Resources Institute (WRI) is a Washington, DC based think-tank devoted to sustainable development. The materials flow framework presented in this report is adapted from a model presented in the year 2000 WRI report *Weight of Nations: Material Outflows from Industrial Economies*.
[4] Franklin Associates. Municipal Solid Waste in the United States: 2000 Facts and Figures: EPA Office of Solid Waste and Emergency Response, June 2002.
[5] See “Total Materials Consumption: An Estimation Methodology and Example Using Lead – A Materials Flow Analysis.” USGS Circular 1183.

Figure 1. Materials Flow Framework



MATERIAL INPUTS

The left side of Figure 1 depicts the material inputs to Washington's economy. Materials can enter the economy as raw materials or in process, component, or finished goods, as defined below.

- **Raw materials** can be extracted (including mining, logging, and harvest) in Washington and added to the economy for processing. Raw materials can also be imported from other states or countries. Most materials, however, enter Washington's economy as process, component, or finished goods imported from other parts of the United States.
- **Process goods** are chemicals and other materials that are essential to product manufacture but are not themselves included in finished goods.
- **Components** are items in various degrees of assembly that will be included in finished goods. Components may be produced in other areas and then assembled into finished goods in Washington, such as parts for aircraft or electronics.
- **Finished goods** are those ready for retail or wholesale trade.

In addition to raw materials, the natural environment also supplies the economy with other vital resources. Energy, air, and water are all necessary for economic processes. However, because the focus of this study is on material wastes, we do not explicitly consider wasted energy, air, or water. We do, however, consider the material flows associated with energy production (such as emissions and coal-mining wastes), and the material, pollutant impacts on air and water.

In addition to resources, the natural environment also supplies services, such as air and water purification through natural biotic processes. These services have significant value, but are not explicitly addressed in this study.

MATERIAL OUTPUTS

Many materials exit Washington's economy as products exported to other states or countries. Just as process, component, and finished goods are imported to Washington, others are exported. The right-hand side of Figure 1 depicts these product exports.

The lower portion of Figure 1 addresses non-product outputs from Washington's economy. The framework depicts three main classes of non-product outputs:

- **Waste types already tracked** (at least to some extent) by Ecology's Solid Waste and Financial Assistance (SWFA) or Hazardous Waste and Toxics Reduction (HWTR) programs. Examples include Municipal Solid Waste and Hazardous Waste;
- **Other outputs not currently tracked** by SWFA or HWTR. These flows include other outputs from the economy such as greenhouse gas emissions, fertilizers spread on fields, and product degradation (such as tire wear or carpet off-gassing). Although not tracked by SWFA or HWTR, some of these flows are tracked by other agencies. These other existing tracking systems will be discussed in Section 3.

- **Extraction wastes** that are left at the point of original extraction or harvest. Examples include mining overburden and tailings, forestry slash, and crop residues.

Note that extraction wastes are not depicted as outputs from the economy. Because they are never purchased, output extraction wastes never enter the economy as defined in this study.[6] Nonetheless, they are closely connected to economic activity, are generated in large quantities, and may have significant environmental impacts.

Specific material flows depicted in Figure 1 include:

- Inputs of process, component, and finished goods
- Inputs of raw materials
- Product outputs
- Municipal Solid Waste
- Construction and Demolition waste
- Industrial waste
- Biosolids
- Moderate Risk Waste
- Toxics release
- Dangerous and Hazardous Waste
- Extraction wastes
- Other flows

Each of these flows will be described in further detail in Section 3.

MATERIAL ACCUMULATION AS STOCKS

Within Washington's economy, material inputs are converted to products. Many of these materials exit the economy relatively quickly as product or non-product (waste) outputs. Other materials, however, accumulate in the economy as highly durable goods or infrastructure (such as roads and buildings). The rate of accumulation of such material stocks is typically faster than the output of those stocks as wastes (e.g., more buildings are constructed than are torn down). As a result, total material input is generally greater than total material output, as some materials are held in long-lived goods and the built environment.

The accumulation of material stocks within the economy is also depicted in Figure 1.

[6] This convention conforms to the model adopted from the World Resources Institute.

MATERIAL TYPES

Materials can be classified under many schemes. In this study, we categorize materials into groups with similar functions in the economy, potential for recovery and use in material cycles, and environmental and/or health impacts.[7] These material types are:[8]

- Plastics
- Glass
- Metals
- Paper
- Wood
- Food
- Fibers and Plant Material
- Petroleum Products
- Persistent Bioaccumulative Toxics (PBTs)
- Biologically Active Compounds (such as spent pharmaceuticals)
- Chemicals
- Composites
- Electronics

Note that electronics and composites consist of combinations of other material types. However, because they are specific combinations that have notable materials and waste management implications, we have defined them separately.

For this exercise, we adopt the terminology of materials-flow thinkers William McDonough and Michael Braungart. In their pioneering book *Cradle to Cradle (2002)*, McDonough and Braungart compare material flows in the economy to nutrient cycles that exist in nature. They divide material flows into two major categories: biological and technical (or industrial).

- **Biological materials** are those that can safely be returned to the soil and consumed by organisms.
- **Technical materials** are those useful in industrial processes. These valuable resources, such as plastic or metal, are typically lost when items are disposed.

In *Cradle to Cradle* McDonough and Braungart write, "To eliminate the concept of waste means to design things – products, packaging, and systems – from the very beginning on the understanding that waste does not exist." Under such a design system, products would be easily deconstructed so that technical materials could re-enter continuous industrial cycles. Few if any products would be hybrids in which technical materials and biological materials were mixed in inseparable combinations.

McDonough and Braungart also identify a third class of materials – "*unmarketables*." These hazardous substances cannot be safely returned either to the soil or to industrial cycles. In "cradle-to-cradle" design, products would not contain unmarketables.

The materials types listed above can be categorized as *biological*, *technical*, or *unmarketable*. These distinctions are displayed in Figure 2.

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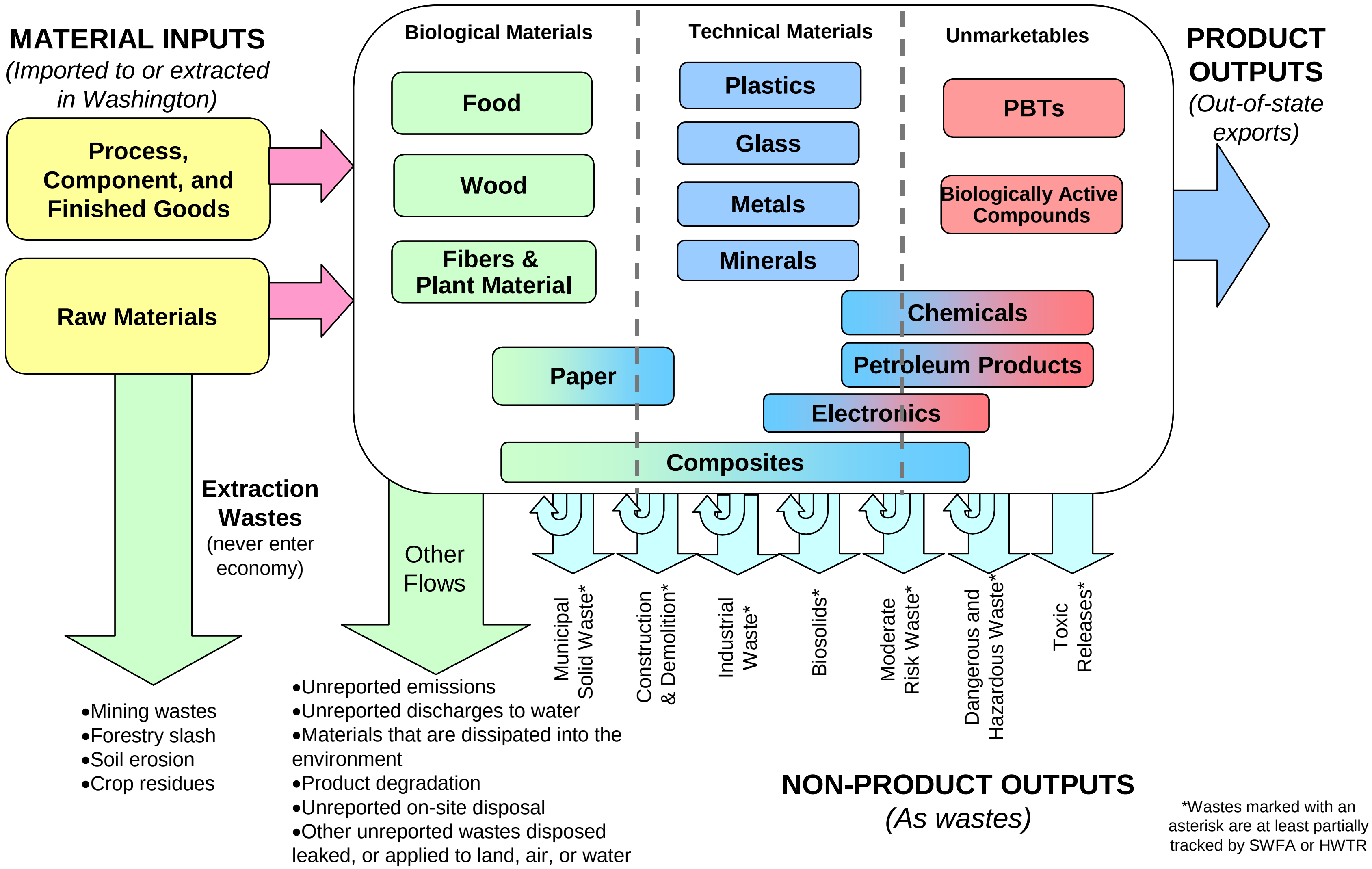
[7] From a waste management perspective, it has traditionally been important to define materials according to categories such as inert, biodegradable, and hazardous. While this classification has proven useful for handling wastes and designing appropriate facilities, it has not always addressed the resource potential associated with those discarded materials.

[8] Note that there is some overlap between categories. In particular, plastics and some hazardous chemicals are also petroleum products.

Figure 2. Material Types



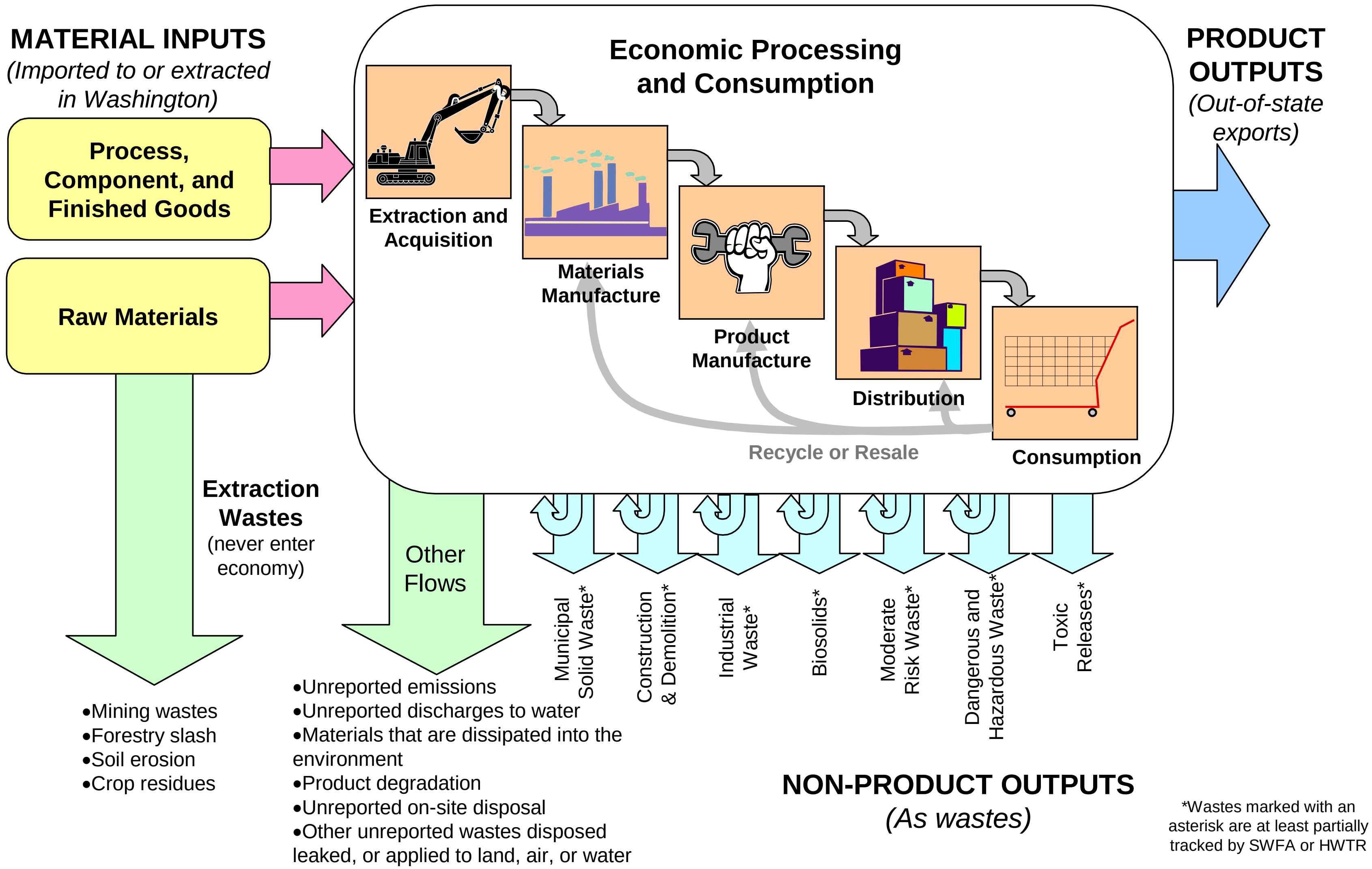
MATERIAL TRANSFORMATION

Raw materials that enter the economy pass through a transformation process on their way to ultimate disposition, reuse, or recycling. This transformation includes the following steps:

- **Extraction and acquisition**, such as extracting coal or acquiring alumina.
- **Materials manufacture**, such as making aluminum ingots from alumina.
- **Product manufacture**, such as making a beverage can out of aluminum ingots.
- **Distribution,** such as shipping and selling beverage cans at retail stores.
- **Consumption,** such as discarding the beverage can.

For any given product, not all of these steps occur in Washington. Imported finished products, for example, skip the first three steps. Nonetheless, all of these processes are occurring in Washington; all require material inputs (as well as water, air, and energy); and all generate waste. Figure 3 depicts the materials transformation process.

Figure 3. Material Transformation within the Economy



ECONOMIC ACTOR SECTORS

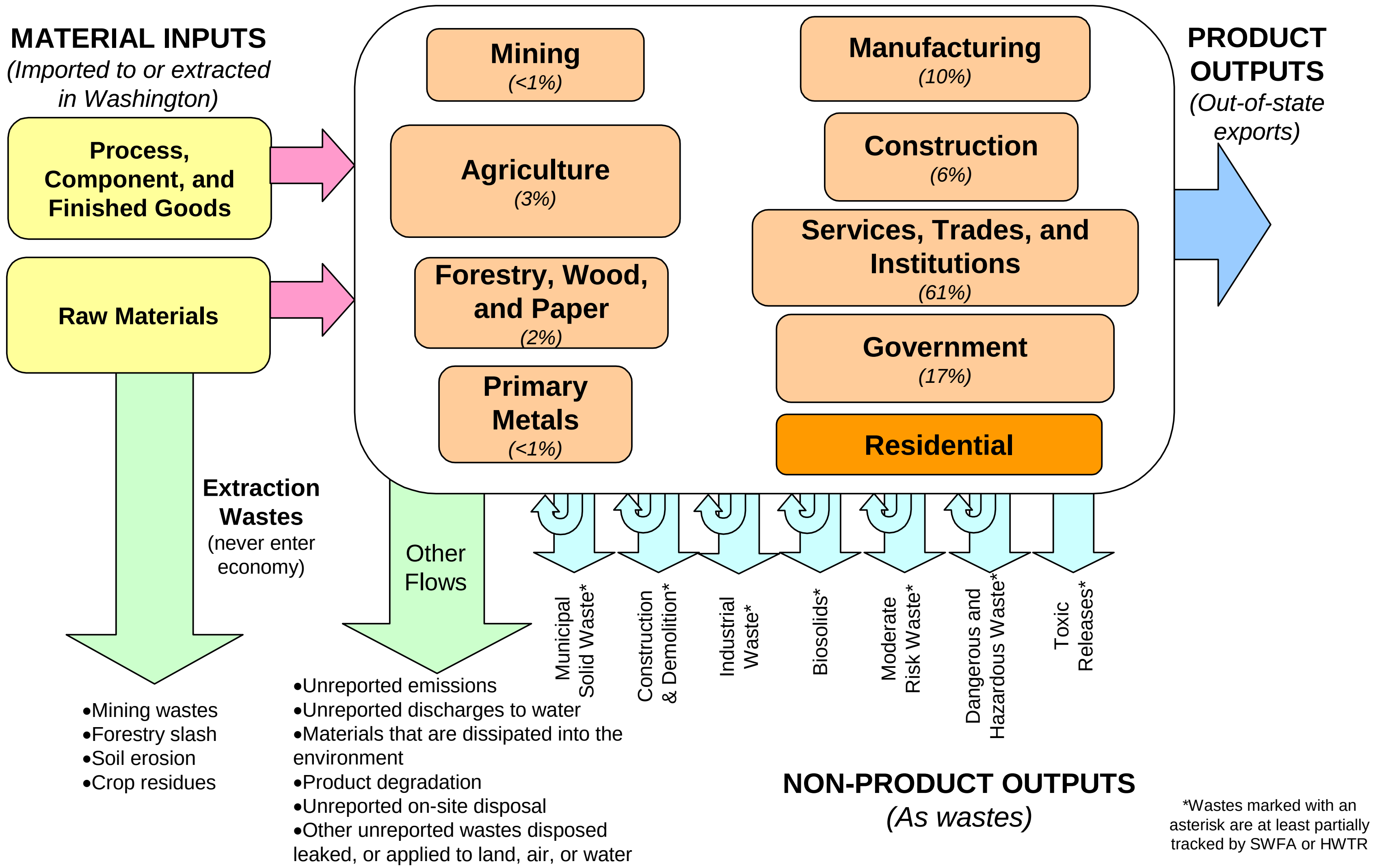
Washington's economy is composed of many entities, ranging from industries to businesses to residents, that manufacture, use, and/or discard materials. Each entity considers many factors in its production and/or use of materials, but many similarities and decision-making criteria emerge. For this study, we define a number of economic actor sectors as being key players in Washington's economy, based on a review of Office of Financial Management economic statistics. These sectors are thought to be somewhat distinct in their approach to materials and wastes. In designing waste reduction and elimination strategies, such as those presented in Consultant Team Issue Papers #3-#5, the consultant will consider the individual wastes and decision-making criteria of each sector, or in some cases, each specific sub-sectors.

Figure 4 depicts the key economic actor sectors, and each sector's approximate share of total Washington's employment, where applicable. Note that a small share of Washington's employment base does not necessarily translate into a small share of the waste outputs. Still, because wastes are generated by the actions of people, we include employment information in order to illustrate the breadth of each sector's involvement in Washington's economy. In addition, the residential sector is depicted (in a different color or shade) because it is a significant waste generator, and its actions often influence the activities of other economic sectors.

Economic Actor Sector	Approximate Share of Washington's Employees
Services, Trades, and Institutions	61%
Government	17%
Manufacturing	10%
Construction	6%
Agriculture	3%
Forestry, Wood, and Paper	2%
Mining	<1%
Primary Metals	<1%
Residential	N/A

Figure 4. Key Economic Actor Sectors in Washington

(Including Percentage of Washington's Employees)



TYPES OF GOODS

Another means of addressing material use and waste production is to consider the types of goods. In this study, we consider the following types of goods:

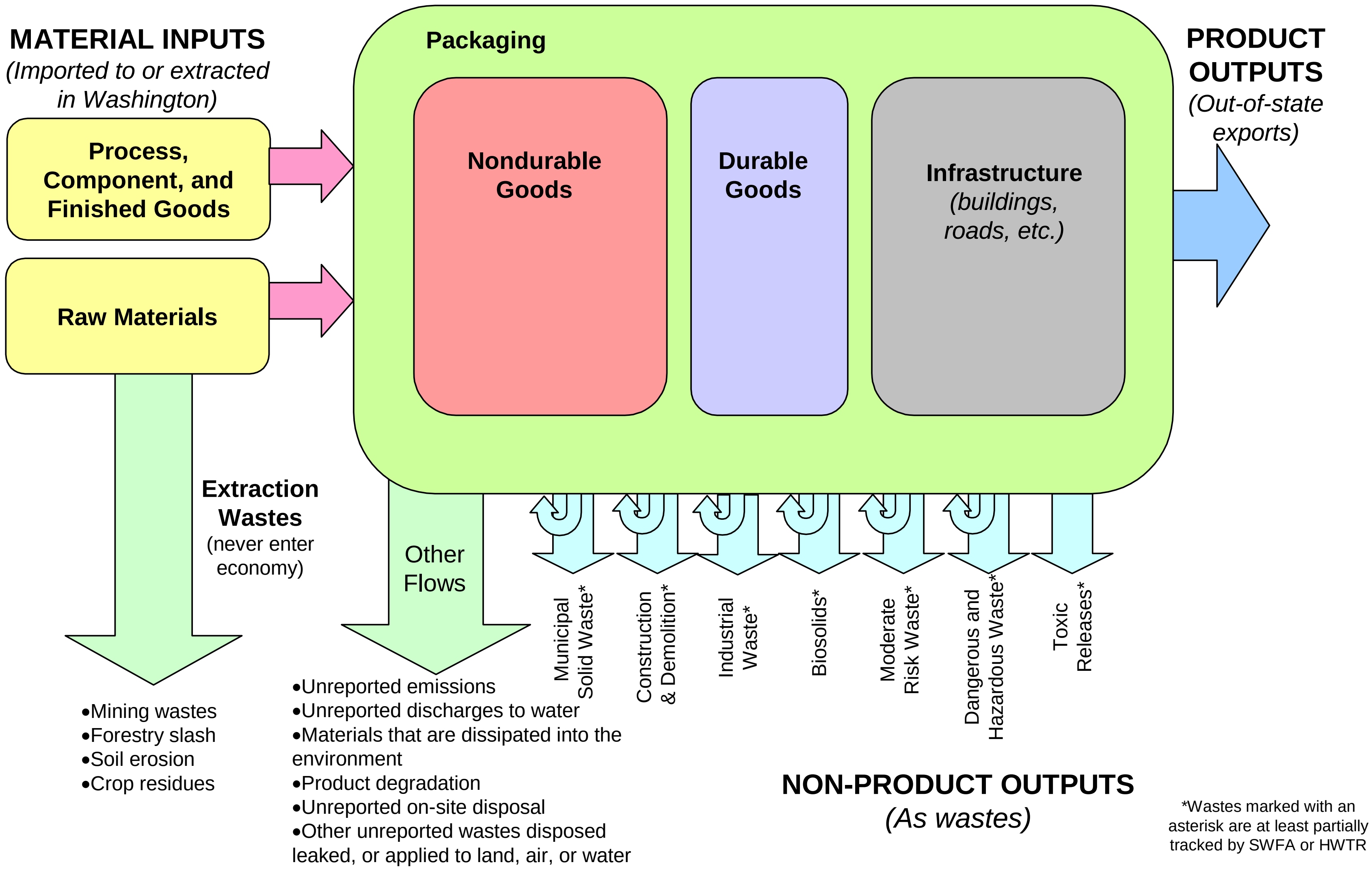
- **Non-durable goods**, those with typical lifetimes of less than three years. Examples of non-durable goods include newspaper, magazines, and clothing. Food can also be considered a non-durable good.
- **Durable goods**, those with lifetimes of three years or longer. Examples of durable goods include appliances, furniture, and consumer electronics.
- **Infrastructure**, materials that become part of the built environment, such as buildings, roads, utility networks, and bridges. Such structures typically last for decades or longer.
- **Packaging.** Almost all durable and non-durable goods (and most infrastructure materials) are contained in packaging at one or more points during their lifetimes.

The U.S. Census Bureau and various industry associations track sales of durable and non-durable goods on a regular basis. Durable, non-durable, and packaging wastes in the United States are estimated on an annual basis by Franklin Associates for the U.S. Environmental Protection Agency.[9]

Since infrastructure lasts for such a long time, most of these products are the wastes of tomorrow – or future generations – not today.

[9] Franklin Associates. Municipal Solid Waste in the United States: 2000 Facts and Figures: EPA Office of Solid Waste and Emergency Response, June 2002.

Figure 5. Types of Goods in the Economy



ORDER OF MAGNITUDE ESTIMATES OF MATERIAL FLOWS

The *materials flow framework* presented in the preceding sections describes the flow of materials through the economy, including the output of wastes. Ecology's Solid Waste and Financial Assistance (SWFA) and Hazardous Waste and Toxics Reduction (HWTR) Programs currently track at least a portion of several waste flows. These include:

- Municipal Solid Waste (including recycling and composting);
- Moderate Risk Waste;
- Hazardous and Dangerous Wastes;
- Biosolids; and
- Toxic Releases.

To a lesser extent, the Ecology programs also track the following waste flows:

- Construction and Demolition Wastes; and
- Industrial Waste.

The quantities of waste tracked in these categories are reported in Ecology's annual status reports, *Solid Waste in Washington State* and *Reducing Toxics in Washington.*

However, many other types of waste and material outputs are not currently tracked by SWFA or HWTR. Some authors have reported that the wastes that consumers and businesses dispose represent only a small fraction of the total wastes associated with our current industrial economy.[10] Such reports lead to questions about what other wastes exist and the importance of monitoring them relative to currently tracked wastes.

Several local and national studies have focused on estimating these other flows. For example, the Washington State Department of Community, Trade, and Economic Development (CTED) has estimated greenhouse gas emissions from the state.[11] As discussed previously, the World Resources Institute (WRI), in Washington, D.C. has undertaken an extensive exercise estimating material flows at the national level. Many of their unit-based standards can easily be combined with Washington data, such as population, to estimate material flows at the state level. Such estimation techniques are not rigorous or detailed enough to support annual trend analysis or specific policy decisions, but they are useful for building order-of-magnitude estimates from which to make broad comparisons.

ESTIMATED FLOW QUANTITIES

Figure 6 shows the largest estimated material flows in Washington, by weight, for the year 2000. Note that:

- **Emissions of carbon dioxide (CO_2) and other greenhouse gases** are the largest category, estimated at nearly 100 million tons; This estimate includes

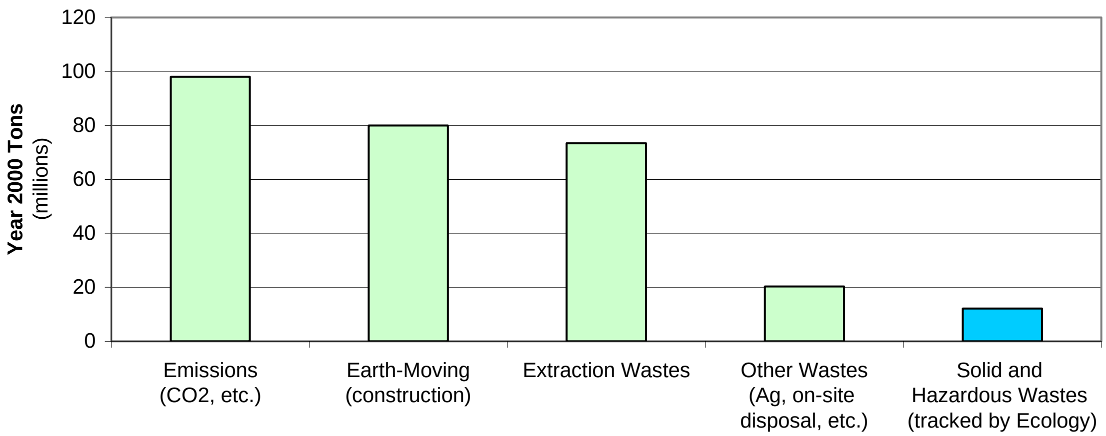
[10] For example, see Hawken, Paul, Amory Lovins, and L. Hunter Lovins, *Natural Capitalism,* Little, Brown, and Company: Boston, 1999 or Brown, Lester, *Eco-Economy,* W.W. Norton and Company: New York, 2001.
[11] See *www.energy.cted.wa.gov/papers/wa-ghg99.htm*. The CTED has since split into two offices: the Washington State Office of Community Development and the Washington State Office of Trade & Economic Development.

quantities of CO_2, NO_x, and SO_2, primarily from the burning of fossil fuels for transportation and energy. Methane was not included as no estimate was immediately available. This estimate also does not include quantities of air pollutants such as volatile organic compounds or fine particulates.

- **Movements of earth** (rock and soil) for construction are approximately 80 million tons;
- **Extraction wastes** (from mining, forestry, and agriculture) are estimated at over 70 million tons;
- **Other output flows**, including fertilizers and manures spread on fields, dredged material, and onsite disposal, among others, amount to nearly 20 million tons; and
- **Solid and hazardous wastes** generated in Washington and tracked by Ecology amounted to less than 13 million tons.[12]

Note that the solid and hazardous wastes generated in WA that are tracked by Ecology represent only a portion of the waste and material outputs of the state.[12]

Figure 6. Estimated Quantities of Waste & Material Outputs in Washington[12]



Following is a series of tables detailing the subflows that comprise each of the above outputs.

[12] Note that Ecology's current tracking systems do not capture some solid and hazardous wastes. To the extent possible, these quantities have been estimated and are included in the "Other" category.

ESTIMATES OF SUBFLOWS

Table 1 presents estimates of key waste and material outputs in Washington in 2000, according to the categories used in Figure 6.

Reported quantities of the waste tracked by Ecology's SFWA and HWTR programs are reported in the annual status reports.[13] All other figures are estimates. Quantities were calculated from either Washington data or national data applied to Washington on a per-unit basis. For a discussion of the methods used to estimate these quantities, see Appendix A.

These estimates are not intended as a list of every material output in Washington. Rather, they are intended to highlight large material outputs for which supporting data were available. Table 2-1 highlights quantity but not inherent hazard or impact. These estimates help place in context the quantities of waste tracked by Ecology's SWFA and HWTR programs. The next section provides a preliminary characterization of the significance and inherent hazard of these flows.

Note that the largest single material output in Washington, by weight, is CO_2 emissions, at approximately 90 million tons. Though not often considered a waste, it is nonetheless a material byproduct and output from the economy formed primarily by the combustion of fossil fuels. The carbon (C) in CO_2 was converted from a liquid to a gas during combustion.

The second largest material flow is earth-moving. This is the estimated quantity of excavation and movement of soil and rock for construction.

Table 1. Detailed Estimates of Key Waste and Material Flows in Washington, 2000

Emissions	**Tons**
CO2	90,000,000
Other gasses	8,000,000
	98,000,000
Earth-moving	**Tons**
Earth-moving	80,000,000
	80,000,000
Extraction	**Tons**
Soil erosion (ag sector)	30,000,000
Coal overburden	20,000,000
Ag losses (crop wastes)	10,000,000
Forestry slash	7,000,000
Other mining	4,900,000
Ag losses (unharvested)	1,000,000
Gold mining	500,000
	43,400,000
Tracked by SWFA/HWTR	**Tons**
Solid waste	7,666,444
Recycling (MSW/Compost)	2,462,772
Recycling (C&D/Other)	1,446,522
Hazardous/Dangerous Waste	186,500
Biosolids	87,717
Toxics Release Inventory	15,854
Moderate Risk Waste -- HHW	9,366
Moderate Risk Waste -- CESQG	532
	11,875,708
Other Waste and Material Flows	**Tons**
Manures	14,000,000
Dredging	4,000,000
Fertilizers	700,000
Sand, salt, slag, and ash on roads	400,000
Untracked biosolids	270,000
Vehicle tire wear	200,000
Other material dissipated to land	200,000
Other to material dissipated to water	20,000
On-site disposal	?
Other sediments	?
Untracked hazardous	?
Biologically active compounds	?
	19,790,000

[13]Except for Biosolids, which was provided by the SWFA program from a database query, and Hazardous/Dangerous Wastes, which were calculated from a data set supplied by HWTR. Note that the quantities reported as "Tracked by SWFA/HWTR" are not necessarily all those that were generated. For example, the Moderate Risk Waste tracked by Ecology is only a portion of that believed to be generated.

PRELIMINARY CHARACTERIZATION OF SIGNIFICANCE

Large material flows do not necessarily produce similarly large environmental or human health impacts. Material flows may have widely varying impacts according to their magnitude, toxicity, and geographic scope. For example, although the quantity of coal overburden is estimated at 20 million tons in 2000, most of this output occurred at one mine in southwestern Washington. Thus, it is expected that the impacts of this material flow are more localized than those of soil erosion, which is a statewide concern with broad implications for resource depletion.

Following is a preliminary "common sense" characterization of magnitude, significance, location, and impacts of some of the key extraction wastes and other materials not currently tracked in the SWFA and HWTR programs. Table 2 characterizes extraction wastes, and Table 3 describes other material flows. These tables are not intended as comprehensive or comparative risk assessments. Rather, they are qualitative descriptions of the location, vigilance required for management, impact, and potential for recovery or reuse of each of these flows.

Characterizations are based on the consultant's judgment after review of the literature, but they are neither scientific nor rigorous enough to support specific policy decisions. Nonetheless, the information contained in these tables is useful for considering the large flows that are currently partially or wholly outside Ecology's current tracking efforts.

Please note that the Vigilance Index is intended to indicate the degree to which a material, product, or waste flow, or the individual chemical substances contained within, are of high concern because they require special (vigilant) management efforts to ensure their production, handling, use, and/or disposition occur within the boundaries of currently accepted environmental and human health risk. The Index is designed to acknowledge that, although such materials can be created, used, and disposed within the bounds of acceptable risk, their inherent hazard creates the need for relatively expensive and complex management efforts susceptible to either inadvertent mistakes or deliberate avoidance. From a cost to society and precautionary standpoint, flows that receive a high vigilance rating are important targets for elimination as products and/or waste streams.[14] For example, biologically active compounds present in sanitary wastewater receive a high vigilance rating because current evidence suggests they have the future potential to be subject to stringent management requirements.

Potential recovery or reuse is characterized as 0 (no potential) through 5 (greatest potential). For example, crop wastes are highly recoverable (rated 5) as a soil amendment, but pesticides are virtually unrecoverable (rated 1), as they are released into the environment.

Please note that the next section presents more detailed discussions of these and other input and output flows.

[14] For a further discussion of the concept of vigilance and the Vigilance Index, see Appendix B, as well as the recommendations presented at the end of Consultant Team Issue Paper #2.

Table 2. Preliminary Characterization of Extraction wastes

Flow	Components	Magnitude (tons if available)	Preliminary Vigilance Index (0-5)	Location	Impact	Potential Recovery or Reuse (0-5)
Coal Overburden	Rock	20,000,000	2	Localized: Only 2 active mines (major mine near Centralia, smaller mine in King County)	Land Use – Potential impacts on habitat/water	1 (Backfill)
Gold Mining	Ore, cyanide	500,000	4	Localized in Northeastern WA	Cyanide is a deadly toxin to wildlife and humans	?
Other Mining	Rock, sand, gravel mining wastes	4,900,000	1	Statewide	Land Use – Potential impacts on habitat/water	3 (Some industrial uses)
Soil Erosion	Topsoil	30,000,000	1	Statewide	Significant resource depletion	4 (Conservation programs)
Agricultural losses (crop wastes)	Discarded stalks, plants, trees, etc.	10,000,000	0 (3 if burned)	Statewide	Beneficial soil amendment unless burned	5
Agricultural losses (pre-consumer)	Harvested and Unharvested food that doesn't make it to consumer	1,000,000	1	Statewide	Beneficial, if composted	5

Table 3. Preliminary Characterization of Other Flows

Flow	Components	Magnitude (tons if available)	Preliminary Vigilance Index (0-5)	Location	Impact	Potential Recovery or Reuse (0-5)
CO_2	CO_2 gas	90,000,000	2 (But more toxic emissions accompany it)	Statewide but affects entire planet; concentrated release from urban areas	Climate change	1 (Photo-synthesis recovers some)
Other gases	SO_x, NO_x, CO, and others	8,000,000	3	Statewide, concentrated release from urban areas	Human and ecosystem health	1
Earth-moving	Excavated soil and rock for road building and construction	80,000,000	1	Localized impact but widely dispersed in suburban & developing areas	Land Use – Potential impacts on habitat/water	2 (As fill)
Dredging	Dredged sediments, including toxics within	4,000,000	2-4	Western Washington, primarily, as associated with waterways	Can contain toxics and impact waterways and wildlife	1
Petroleum-contaminated Soils/other sediments	Sediment, including toxic contaminants	?	3	Dispersed statewide	Potential impacts on habitat/water if not properly managed	2
Untracked hazardous	Hazardous wastes that are not tracked or reported	?	4	Dispersed statewide	Significant impacts to human, ecological health if not properly managed	2
Fertilizers	Nitrogen, Chemicals, metals	700,000	3	Statewide	May have impacts to human, ecological health	1
Pesticides	Chemicals, metals	?	3	Statewide	Significant impacts to human, ecological health	1
Manure	Manure	14,000,000	2	Statewide	Pollutes waterways and contaminates groundwater	3
Sand, salt, etc. on roads	Sand, salt, slag, ash, some toxics	400,000	2	Mountain passes & Eastern Washington	Can contain toxics and impact waterways and wildlife	2
Biologically Active Compounds	Pharmaceuticals and other agents	?	3	Statewide	May affect reproduction and development of humans and animals	1

3. Characterization of Material Flows and Wastes in Washington

The *materials flow framework* discussed in the preceding section presents several categories of input and output flows. This section characterizes each of these flows, where information is available, in terms of the following topics:

- Composition and sources;
- Quantity and inherent hazard;
- Significance; and
- Available tracking systems and information gaps.

For Beyond Waste planning, this information is necessary to describe the “universe of wastes” that a new or updated tracking system will need to measure and understand. But in addition, future planners and researchers can use this information to gain a broad understanding of the waste and material flows in Washington -- where they originate; what they are; how much and how hazardous they might be; how significant they are; and how they currently (or might be) tracked or estimated.

MATERIAL INPUTS

Material inputs fall into two main categories:

- Raw Materials; and
- Process, Component, and Finished Goods.

INPUTS OF RAW MATERIALS

Sources and Composition. Raw materials are extracted from the natural environment of Washington, but they are also imported from other states and foreign countries. Key raw materials extracted in Washington include wood; agricultural crops; and rock, clay, and sand. Ores for magnesium, lead, zinc, gold, and silver, as well as coal deposits and gemstones come from within the state’s borders.[15] Key raw materials imported to Washington include alumina for production of primary aluminum, agricultural crops, and petroleum, among others.

Quantity and Inherent Hazard. The total quantity of raw material imports is unknown, and the inherent hazard varies according to material. Some raw materials may be more toxic than expected. For example, in 2000 a Washington fertilizer company imported zinc sulfate from China. This material was found to have extraordinarily high levels of cadmium, many times Washington’s acceptable levels.[16]

Significance. The extraction of raw materials, both within and outside of Washington, can generate significant quantities of waste and exert tangible environmental impacts.

[15] The Pend Oreille lead-zinc mine has not operated since 1977. However, Cominco American plans to reopen the mine in 2002 or 2003 and anticipates an annual production of 93,000 tons of zinc and 14,300 tons of lead in concentrate.
[16] Washington State Department of Ecology. *Imported Cadmium-Contaminated Zinc Sulfate Used in Fertilizer and Other Products.* Department of Ecology Focus 00-04-025, July 2000.

Toxics that are imported with raw materials can be mobile and be dispersed into the environment. In portable form, toxics can expose workers and neighboring communities. Of particular concern are toxics embedded in materials that are intended for release into the environment, such as heavy metals in fertilizers.

Tracking Systems. Extraction of raw materials within Washington is fairly well documented through a variety of organizations. Currently, the Washington State Department of Natural Resources publishes an annual report on Washington's mining industry in *Washington Geology*.[17] The U.S. Department of Agriculture tracks Washington production of agricultural commodities, and forest industry associations track wood production. The combination of these information sources provides the basic ability to track raw material extraction in Washington over time. However, no comprehensive system exists for tracking raw material imports to Washington.

INPUTS OF PROCESS, COMPONENT, AND FINISHED GOODS

Sources and Composition. Process, Component, and Finished Goods are imported to Washington from other states and countries. Process goods, such as process chemicals, are substances required for product manufacture that are not contained in the finished good. Components are items that are combined with other inputs and assembled into finished goods in Washington. Finished goods are items ready for resale. As all imported goods are combinations of various raw materials, it is often difficult to track their constituents. This situation may be of particular concern because few regulations address hazardous substances contained within products.

Quantity and Inherent Hazard. Millions of tons of process, component, and finished goods are imported to Washington annually. Some may contain hazardous substances, but little information exists regarding quantities of toxic or other materials contained therein.

Significance. As per-capita consumption of goods increases and Washington, like the rest of the U.S., becomes a more service-based economy, more manufactured goods will need to be imported. Consequently, in the context of the Beyond Waste vision, it will become increasingly important to understand what materials those goods contain as well as the environmental and health effects associated with their use and disposal. Furthermore, it may be important to consider the environmental impact of resource extraction and product manufacture in the regions that produced the imported products.

Tracking Systems. As with raw materials, no comprehensive system exists for tracking the quantities of imported goods to Washington from other states or countries. At the national level, the U.S. EPA, in consultation with Franklin Associates, estimates product imports to the U.S. as part of their annual study of Municipal Solid Waste. Their research relies on the U.S. Department of Commerce, the U.S. Census Bureau, and in particular, key businesses and industry associations. This research does not document product constituents. In this regard, the U.S. Department of Commerce, in consultation with the United States Geological Survey, has developed a method to measure the amount of material contained in imported goods to the United States.[18] Although most applicable at a national level, the method may have utility for Washington. For example,

[17] *Washington Geology* is available on-line at *www.wa.gov/dnr/htdocs/ger/washgeol.htm*.
[18] For a detailed example of this methodology, see "Total Materials Consumption: An Estimation Methodology and Example Using Lead – A Materials Flow Analysis." USGS Circular 1183: 1999.

applying the USGS method to Washington State's mercury use could establish the quantity of mercury within products entering Washington each year.

One possible source of data on inputs of goods comes from product sales data generated by the use of bar codes in retail establishments. Product sales information is available for retail sales in major markets such as Seattle.[19] However, based on discussions with A.C. Nielsen and Census Bureau staff, the consultant believes the current system is not comprehensive enough to enable statewide projections of unit sales of specific products.

PRODUCT OUTPUTS

OUTPUTS OF RAW MATERIALS

Sources and Composition. The primary outputs of raw materials from the state's economy are forest and agricultural commodities. In addition, other raw materials are extracted in Washington as discussed under Inputs of Raw Materials. These items are also sold and exported to customers outside Washington.

Quantity and Inherent Hazard. Over 59 million tons of raw and product materials were shipped to other states from Washington in 1997, according to the Economic Census, completed every five years (2002 data was not yet available as of the completion of this report) by the U.S. Department of Transportation and the U.S. Department of Commerce.[20] The fraction of raw materials in this total, however, is unknown. Forest and agricultural commodities have minimal inherent hazards, but some commodities mined in Washington, such as lead and silver, are notable sources of heavy metals and other PBTs.

Significance. The export of raw materials from Washington is less relevant to the Beyond Waste vision than the processes that produce these materials within Washington and the local implications for resource depletion. However, exported materials may become wastes in other states or countries, with potential environmental and human health impacts in those areas. Strategies to address toxics within Washington might also help reduce the health and environmental impacts associated with these exported materials.

Tracking Systems. The consultant knows of no current comprehensive system to track raw material exports. However, industry associations track sales of forest and agricultural commodities from Washington. Also, the Economic Census, mentioned above, is completed every five years.[20] A component of this survey is a transportation survey that tracks commodity flows by state of origin. This survey could provide periodic information on Washington's raw material exports.

OUTPUTS OF PROCESS, COMPONENT, AND FINISHED GOODS

Sources and Composition. Outputs of goods occur primarily from Washington's Manufacturing, Forest and Wood Products, and Primary Metals economic sectors.

[19] A.C. Nielsen projects retail sales for major markets but not for states or other geopolitical boundaries. Projections for the Seattle area are based only on sales at large, chain grocery stores. Other retailers are not included.

[20] A component of the Economic Census is a Commodity Flow Survey. The 1997 Commodity Flow survey was issued in December 1999 and is available on-line at *www.census.gov*.

These sectors primarily export aerospace, wood and paper, and aluminum products. In addition, software and other information technologies are exported from the state, although the material exports from this sector are relatively minor.

Quantity and Inherent Hazard. As stated above, over 59 million tons of raw and product materials were shipped to other states from Washington in 1997, according to the Economic Census, completed every 5 years. But the fraction of process, component, and finished goods in this total is unknown. As with imported goods, exported goods may contain hazardous materials.

Significance. As with exported raw materials, the export of goods is less relevant to Beyond Waste planning than the local impacts of product manufacture. However, exported products may become wastes in other states or countries, with subsequent potential environmental and human health impacts in those areas.

Tracking Systems. While various institutions concerned with trade track sales and exports of Washington products, such tracking is typically denominated in dollar values, not tons. As noted above, the Economic Census reports quantities of commodities shipped that originated in Washington. For example, in 1997 over 4 million tons of fertilizers were produced and shipped in Washington. However, the Census does not report how many of those tons remained within Washington versus were exported to other states.

NON-PRODUCT OUTPUTS

HAZARDOUS WASTE AND MATERIAL FLOWS

Toxic Releases

Sources and Composition. Chemicals are released to the environment via air, water, and land pathways during the extraction, transport, manufacture, process transformation, use, or disposal of materials and products. The Toxics Release Inventory (TRI) database was established under Section 313 of the federal Emergency Planning and Community Right-to-know Act of 1986 to track and better understand releases by certain industries of more than 600 chemicals known to have adverse human health or environmental effects. These chemicals demonstrate the following types of characteristics:

- carcinogenicity;
- persistence in the environment;
- bioaccumulation;
- or impairments of reproductive, digestive, neurological or other critical life-support functioning.[21]

In Washington State, key industries that report releasing toxic substances in 2000[22] include the pulp and paper industry, primary metals manufacturers (mainly aluminum plants), electric utilities, chemical and allied product manufacturers, and petroleum

[21] See, for example, *www.epa.gov/tri/chemical/#ToxicityInfo*, the National Institute of Occupational Safety and Health's *Registry of Toxic Effects of Chemical Substances*, or the June 28, 2002, California Proposition 65 List of Chemicals for descriptions of the toxic characteristics of TRI-listed substances.
[22] Toxics Release Inventory 2000 Data, *www.epa.gov/tri/tridata/tri00/state/Washington.pdf*.

refining and related industries. Many non-industrial, diffuse sources (including cars and trucks) that may also release toxic chemicals to the environment are not monitored or tracked under TRI. As a result, less is known about the quantities, chemical composition, and distribution of their releases.

Washington State TRI facilities reported releasing more than one ton of methanol, barium compounds, ammonia, hydrochloric acid, nitrate compounds, and carbonyl sulfide in 2000. Volumes of at least four persistent, bioaccumulative, and toxic substances of special concern were also reported in 2000.

Quantity and Inherent Hazard. According to 2000 TRI data, Washington State Facilities reported releasing approximately 15,854 tons of federally-monitored chemicals to the air, land, and water. Altogether, 84% was reported as being managed onsite: 62% of these releases were to air; nine percent to surface waters; and 13% were released to land for onsite management. The remaining 16% of all reported toxic releases represent materials sent offsite (for storage, wastewater treatment, landfilling or treatment, or other management).

Significance. Toxic chemicals that enter the environment directly via air emissions (e.g., certain metal dusts or volatized metals) and water releases (direct discharges to surface waters or via Publicly Owned Treatment Works) or indirectly (via soil migration/groundwater leaching resulting from improper management) can pose environmental and human health threats. It is, in part, for this reason that EPA has established a detailed regulatory framework to restrict, direct and track the transfer, management, and release by industries of toxic chemicals that the agency considers to be of significant concern.

Under TRI, manufacturing and extraction industries that meet a toxic substance activity threshold are required to report quantity, and release and management information for the specific, listed chemicals of greatest concern, such as the PBTs. Although it is important and useful by itself, TRI information alone cannot be used to characterize environmental and human health hazard or risk. However, these data do provide important information about the location, type, and magnitude of toxic chemical releases and can be used in conjunction with other data to evaluate exposure pathways and risk posed by specific chemicals to human populations and the environment.

Tracking Systems. Certain industries are required under federal law (EPCRA Section 313)[23] to report, on an annual basis, the quantities of specified chemicals that they release to air, water, and land. In Washington State, this information is stored on Ecology's EPCRA system, Toxics Release Inventory (TRI) Master database.

TRI covers approximately 667 chemicals, including certain PBTs, and focuses on those chemicals that can cause chronic human health and environmental effects, although chemicals that may cause acute effects are also included. TRI reporting does not capture all toxics chemicals, nor does it require all industries (or even all facilities within an industry) to report. Facilities must be of a certain size (more than ten employees) and

[23] Emergency Planning and Community Right-to-know Act (EPCRA) Section 313 requires EPA and the states to collect data annually on releases and transfers of certain toxic chemicals from industrial facilities and make the data available to the public in the Toxics Release Inventory (TRI). Currently, 582 chemicals individually listed chemicals and 30 chemical categories are tracked under TRI. Industries falling under SIC Codes 20 through 39, as well as the metal and coal mining, electric utilities that combust coal or oil, petroleum bulk plants and terminals, solvent recovery services, RCRA Subtitle C hazardous waste treatment and disposal facilities, chemical wholesalers, and federal facilities, are required to report under TRI.

meet certain activity thresholds related to their use or generation of listed toxic chemicals to meet TRI submittal requirements. TRI reporting facilities are allowed to estimate the quantities of chemicals they release. As well, the TRI regulations do not require facilities to report chemical release concentrations nor the quantity of chemicals consumed during manufacturing. TRI does not necessarily provide information on releases during manufacture or use of a product, nor the quantity of a toxic substance incorporated into a product. Nor does TRI track releases from diffuse, smaller sources (like cars, households, or businesses using smaller quantities of materials). As such, it does not provide a complete picture of total toxics placed into the environment.

Used alone, TRI cannot establish the health or exposure risks of specific chemical releases.

Release information is also captured in pollution prevention plan reports prepared each year by facilities that meet specific hazardous waste substance use and/or hazardous waste generator requirements. In part, the report requires facilities to report volumes of TRI- (or Montreal Protocol-) listed substances released, recycled, or treated in the previous year. This information may possibly be used to supplement the TRI release information.

Dangerous and Hazardous Wastes[24]

Washington State Dangerous Waste rules require all establishments generating Dangerous Wastes (irrespective of quantity) to notify the Department of Ecology of this activity and receive and maintain a Dangerous Waste identification number. Dangerous Waste management and reporting requirements for generators vary depending on the volume of generation. Large Quantity and Medium Quantity Generators (LQGs and MQGs, respectively) are subject to onsite management and handling requirements and must manifest their waste sent offsite to permitted facilities for management. As well, they must annually report generation and management volumes and activities to the Department of Ecology. Small Quantity Generators (SQGs) are not required to report their Dangerous Waste activity and volumes to Ecology, although they must verify their generator status annually. The Department of Ecology's Dangerous Waste data system (HWIMSy) indicates that in calendar year 2000 there were 617 active LQGs, 797 active MQGs, and 3,354 active SQGs in 2000.

Sources and Composition. Dangerous Waste consists of non-product outputs generated during product production and service delivery activities. These wastes, which are regulated from "cradle to grave" under the federal Resource Conservation and Recovery Act (RCRA) and Washington State Dangerous Waste rules, come in a variety of forms including inorganic liquids (e.g., aqueous acid waste), organic liquids (e.g., solvent-water solutions), inorganic solids (e.g., reactive cyanide salts/chemicals), organic solids (e.g., solid resins), inorganic sludges (e.g., plating sludge with cyanides), organic sludges (e.g., still bottoms of halogenated solvents), and, to a more limited extent, inorganic and organic gases.

Large and Medium Quantity Generator industry types that account for the majority of Dangerous Waste generation in Washington include the primary metals industries (SIC-33), chemicals and allied products (SIC-28), aerospace (SIC-373), petroleum refining

[24] Please see Appendix C for a more detailed discussion of 2000 dangerous waste generation and management trends.

(SIC-29), government operations, including military installations (SICs-91 to 97), electrical and electronic equipment (SIC-36), and services (SICs-70 to 89).

Major Washington State SQGs include small vehicle maintenance operations, metal fabrication and finishing operations, printers and photographic finishers, pesticide users and applicators, laboratories, and construction operations. In general, various types of cleaning operations (e.g., dip rinsing) are typical sources of SQG Dangerous Waste; various forms of cleaning materials (e.g., organic solvents) are the associated typical waste forms.

In calendar year 2000, 79 percent of reported waste generation was associated with six forms of waste: B319 – Other Inorganic Liquids (19,300 tons); B511 – Air Pollution Control Device Sludge (19,300 tons); B606 – Resins, Tars, and Tarry Sludge (15,600 tons); B409 – Other Nonhalogenated Organic Solids (11,800 tons); B404 – Spent Carbon (9,600 tons); and B316 – Other Metal Salts/Chemicals (3,600 tons). A substantial portion (27,700 tons or approximately 28 percent) of the waste was reported associated with highly generic sources of waste: Source Code A59 – Other Production-Derived One-Time and Intermittent Processes; Source Code A99 – Other; Source Code A56 – Discontinue Use of Process Equipment; and Source Code A09 – Clean Out Process Equipment.

Quantity and Inherent Hazard. Ecology's HWIMSy data system indicates that 186,500 tons of Dangerous Waste were "generated" in the state in 2000.[25] This total excludes waste generated by the United States Department of Energy's Hanford Facility and permitted, commercial treatment, storage, disposal, and recycling facilities (TSDRs).[26] Also excluded are wastes that are generated by small quantity generators. Of this, 171,300 tons were classified as "recurrent" waste (those that are directly produced by production or service processes or result from the treatment of hazardous or non-hazardous waste) and 15,200 tons were classified as "non-recurrent" waste (those associated with spill cleanups, one-time equipment decommissioning, or other remedial cleanup). The HWIMSy data system indicates 99,814 tons of primary, recurrent, non-wastewater, and non-mixed radioactive wastes were generated during 2000.[27] Permit by Rule (PBR), Treatment by Generator (TBG), and Mixed Radioactive wastes totaled 22,619, 16,745, and 33,992 tons, respectively.[28]

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[25] Under the Dangerous Waste reporting rules, generators report the waste they managed during the reporting year. Technically the data do not represent calendar year generation because waste generated previously but managed during the reporting year are captured and waste generated during the reporting year but managed in future years are not captured.

[26] Ecology typically removes Hanford from waste generation totals given the unique nature of the facility, its wastes, and related clean-up activities and TSDR wastes because these wastes typically result from the management of other Dangerous Wastes received from offsite for treatment and are thus deemed "secondary" generation.

[27] Ecology typically looks to discern recurrent waste generation by removing volumes associated with hazardous wastewaters - those flagged in the HWIMSy data system as Treatment by Generator or Permit by Rule - and mixed radioactive wastes. Wastewaters, because they often reflect high volumes of liquid with relatively low concentrations of Dangerous Waste constituents, can distort generation totals, and mixed radioactive wastes represent a unique waste stream subject to regulation under the Nuclear Regulatory Act.

[28] These three totals plus the primary, recurrent total of 99,814 tons exceed the overall recurrent waste estimate of 171,300 tons by 1,870 tons. This discrepancy likely results from certain waste volumes being associated with more than one of the indicators – PBR, TBG, Mixed – used to isolate these volumes in the data set.

Significance. Dangerous Wastes, by definition, are materials deemed to be of very high environmental and public health concern if handled inconsistently with federal and state regulatory requirements. Although such materials can be created, routed to reuse or recycling, and/or disposed within the current bounds of acceptable risk, their high inherent hazard creates the need for relatively expensive and complex management efforts subject to either deliberate avoidance or inadvertent mistakes. Certain dangerous wastes are also subject to the potential for variability in the management efforts typically undertaken for them. This occurs because, under federal and state dangerous waste regulatory requirements, the nature of management requirements are tied in part or whole to the volume of waste generated and/or disposition methods selected. As well, SQGs are subject to reduced management requirements even though the waste material is identical from an inherent hazard standpoint and the preferred management is identical to that required for Medium and Large Quantity Generators. The lower regulatory requirements may be due to a combination of factors including lower quantities producing less exposure potential and the practical and economic constraints on regulating small, diffuse sources. Additionally, wastewaters containing dangerous wastes can be disposed through public wastewater treatment systems subject to a different type of management requirements largely imposed by Clean Water Act pretreatment and biosolids quality standards. From a precautionary standpoint, the identified need for intensive and complex management coupled with the potential for variable management not always consistent with preferred management practices, makes dangerous wastes a high priority for elimination efforts

Tracking Systems. Since 1995, Ecology has used the Hazardous Waste Information Management System (HWIMSy) to track annual dangerous waste generation and management activities. HWIMSy automates data received annually from dangerous waste generators (excluding SQGs) and permitted TSDR facilities via the Dangerous Waste Annual Report. Dangerous waste generators report the types, forms, sources, and volumes of dangerous waste moved to management during the reporting year and indicate the location and type of management the waste received. Some wastes are exempted from reporting requirements, including universal wastes (such as lamps, batteries and mercury-containing thermostats), materials managed under the used oil regulations, and other materials excluded under federal or state statutes or requlations.

TSDRs report the type, form, and quantity of dangerous waste they receive for management during the reporting year and identify the type of management these wastes received. HWIMSy also contains limited information on dangerous waste generators that have indicated through an annual notification process that they are SQGs and, therefore, are not required to report waste generation activity.

NON-HAZARDOUS WASTE AND MATERIAL FLOWS

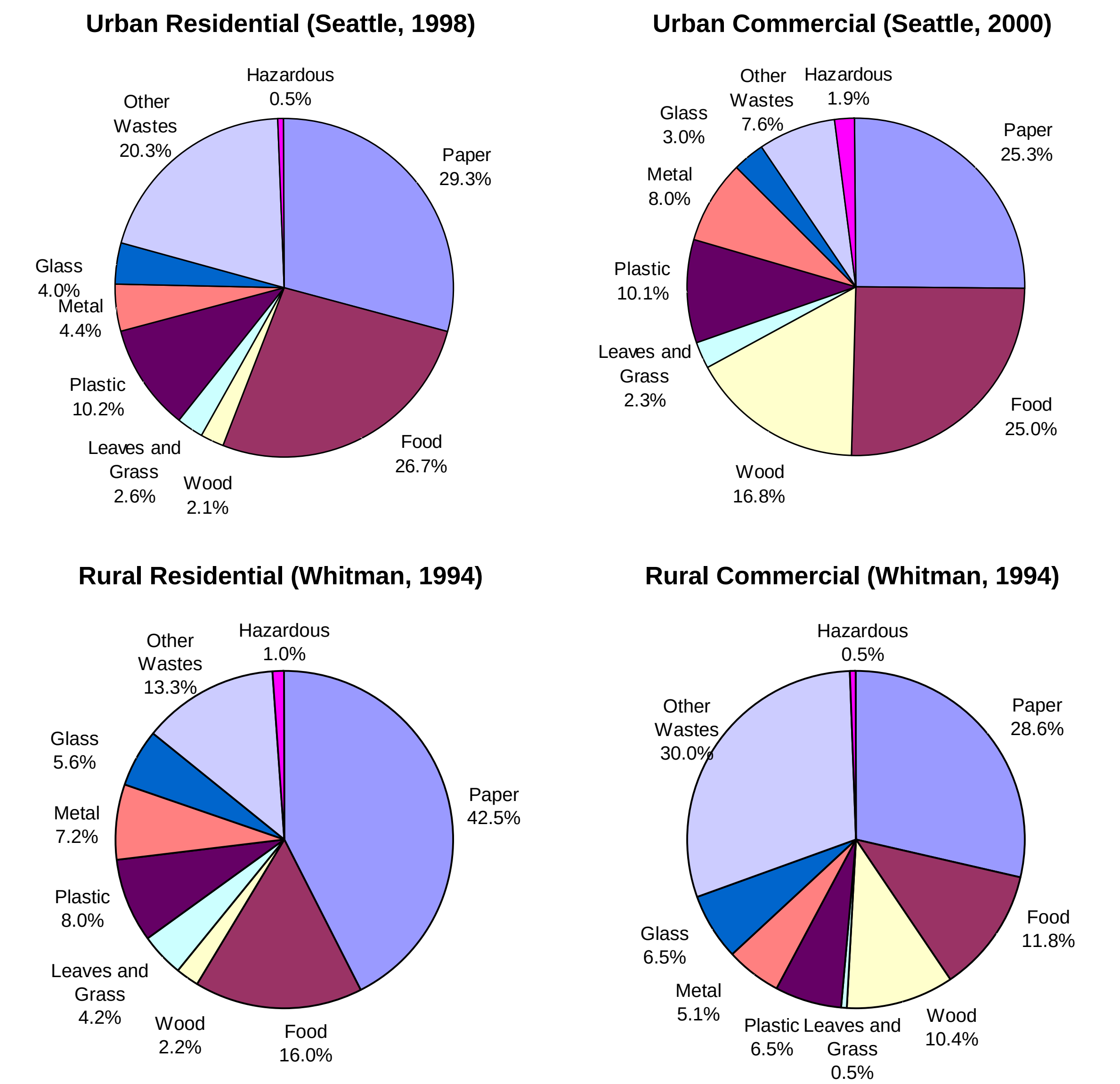
Municipal Solid Waste

Sources and Composition. Municipal Solid Waste (MSW) refers to household, commercial, and industrial solid waste. In the United States, disposed municipal solid waste is typically composed of, in decreasing order of weight, discarded packaging, non-durable goods, durable goods, yard waste, food, and other materials.[29] Figure 7 shows

[29] Franklin Associates. *Municipal Solid Waste in the United States: 2000 Facts and Figures*: EPA Office of Solid Waste and Emergency Response, June 2002.

some sample waste compositions, by material type, from the City of Seattle and from Whitman County. Note that in all cases over half of the waste is composed of biological materials, as defined in Section 2.

Figure 7. Sample Compositions of Residential and Commercial MSW



"Other Wastes" include composite materials, electronics, rock and concrete, furniture, and other miscellaneous items.

Quantity and Inherent Hazard. In the year 2000, a reported 6,263,442 tons of waste were generated in Washington for disposal at MSW facilities.[30] An additional 2,462,772

[30] As reported in *Solid Waste in Washington State, Tenth Annual Status Report*, published by Ecology's SWFA program. According to the report, 4,610,914 tons was classified as municipal solid waste, with the remainder classified as industrial, inert, asbestos, petroleum contaminated soils, or construction/demolition waste.

tons of MSW were recycled and composted. Although MSW is not classified as hazardous, some of its components may be hazardous or toxic.[31] In particular, thousands of tons of hazardous chemicals are disposed as MSW by businesses in Washington annually (over 4,000 tons in Seattle alone, as reported in the City of Seattle's 2000 Commercial Waste Composition Study[32]). Furthermore, hundreds if not thousands of tons of household hazardous waste, such as batteries, paints, cleaning products, pesticides, and motor oil are disposed annually in Washington's residential waste stream.[33] In addition, some disposed products contain toxic substances that are not measured or addressed by standard waste composition studies.

Significance. Municipal solid waste is the most visible waste stream. Waste management efforts have historically focused on managing, reducing, and recycling MSW. While recycling programs have been fairly successful (particularly in Washington), the total quantity of MSW disposed has continued to rise. Programs to divert hazardous items to dedicated collection facilities have also been somewhat successful, but many thousands of tons of such materials remain in MSW, as discussed above.

Tracking Systems. Section 173-304 of the Washington Administrative Code, Minimum Functional Standards for Solid Waste Handling, requires tonnage reporting for permitted landfills and incinerators that accept MSW. MSW disposal reporting is generally quite effective. SWFA issues annual reports on the quantities of MSW wastes disposed, incinerated, and imported from or exported to other states. These reported figures are used to chart progress and to calculate (along with recycling totals) the state recycling rate. However, several issues reduce accuracy:

- Three landfills do not have scales with which to weigh disposed MSW. They use conversion factors to estimate tonnages based on the volume of waste disposed.
- Categories on the reporting form are poorly defined and are often used incorrectly by reporting facilities. As a result, many waste types (such as industrial or construction and demolition) are reported as MSW.

Recycling of MSW materials is tracked by a voluntary annual survey of collectors and haulers. While the survey is effective at obtaining basic information about quantities of materials collected for recycling in the state, it is difficult to discern whether perceived trends are actual changes or simply variations in survey response. Again, two issues reduce accuracy:

- Many recycling companies (particularly those that handle metals, construction/demolition, and tires) refuse to report quantities.
- Some MSW intended for disposal is actually recycled after it enters the disposal facility. These quantities are sometimes not reported. When they are reported, they may be counted twice (as both disposal and recycling).

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[31] In many cases, disposing small quantities of hazardous waste in the solid waste (MSW) stream is legal due to the exemption of small-quantity generators (SQGs) from certain Hazardous Waste requirements. Therefore, it is likely that much of the hazardous waste reported in MSW waste composition studies was legally disposed by the generator.

[32] Cascadia Consulting Group, *2000 Commercial Waste Stream Composition Study: Final Report*: Seattle Public Utilities, in preparation 2002.

[33] For information on household hazardous waste disposed in Seattle's residential waste stream, see: Cascadia Consulting Group, *1998/1999 Residential Waste Stream Composition Study: Final Report*: Seattle Public Utilities, Feb. 2000.

Construction and Demolition Waste

Sources and Composition. Construction and Demolition (C&D) is waste generated by the construction and demolition of buildings, roads, and other infrastructure. C&D consists largely of concrete, wood, metal, paper, roofing, and drywall. Some C&D is recycled or diverted, some is disposed at dedicated inert/demolition landfills. Other C&D waste is disposed of at normal, MSW landfills.

Quantity and Inherent Hazard. In 2000, 477,383 tons of waste were reported disposed at Washington's 28 inert/demolition landfills, and 280,310 tons of inert, demolition, or wood wastes were dispose at limited purpose landfills. An additional 588,588 tons of inert/demolition waste were disposed at MSW landfills; however, some facilities include demolition and inert wastes in their MSW totals, so this number is certainly low.[34]

In addition to C&D that is disposed, large quantities are diverted from disposal, particularly concrete, wood, and metal. A reported 893,218 tons of concrete and asphalt; 14,412 of roofing shingles; and 376,684 tons of other C&D were diverted in 2000.[34]

The inherent hazard of C&D materials varies. While most are fairly benign, there are many notable exceptions. Liquid paint is occasionally disposed in the C&D stream, as are other chemicals and asbestos. Painted, stained, treated, and composite wood products may also pose problems, particularly when they are incinerated for energy recovery. Recently, the EPA has announced a phase-out of lumber treated with chromated copper arsenate because it releases arsenic, a carcinogen.

Significance. C&D diversion has grown steadily over the past 10 years as markets have developed for concrete and wood wastes. While these programs are largely successful, they face many challenges, including removal of contaminant and hazardous materials from C&D streams. Future C&D recycling may be further compounded by the industry trend towards composite building materials made out of both biological and technical materials. For example, new wood-plastic composite sheathing products are quickly entering the market. Although they use recycled feedstocks (plastic film), they may not themselves be easily recyclable. This underscores the point that today's building materials can become tomorrow's wastes – infrastructure and buildings contain large fixed stocks of materials that may not become waste for decades.

Tracking Systems. SWFA tracks the quantities of demolition and inert waste disposed at permitted facilities. However, unknown quantities of C&D waste are reported as MSW. SWFA's annual recycling survey collects information on C&D recycling, but this information is not comprehensive. Local studies (such as that recently completed by King County Solid Waste Division) can provide further information on C&D disposal and recycling totals. Local studies also provide characterization of C&D waste that may be extrapolated to the state level.

Industrial Waste

Sources and Composition. Industrial waste refers to wastes and byproducts generated by Washington industry, especially the manufacturing, primary metals, and forestry/wood/paper sectors. When disposed at landfills or incinerators, industrial solid wastes are often considered as MSW. Other industrial flows are not typically captured

[34] As reported in Solid Waste in Washington State, Tenth Annual Status Report, published by Ecology's SWFA program.

by the waste management system. Large quantities of industrial byproducts are used as inputs to other processes, often at other companies. Other industrial wastes are treated onsite. Common industrial wastes in Washington include paper pulp sludges, furnace ash, pot liner wastes from aluminum smelting, and oil refinery sludges. Food processing wastes such as fruit pomace, carcasses, oils, and potato scraps may also be considered industrial wastes.

Quantity and Inherent Hazard. According to SWFA's 10th Annual Status Report, 88,841 tons of industrial wastes were disposed at MSW landfills in 2000. The actual total may be higher, however, due to incorrect use of reporting categories on annual facility reporting forms, as discussed under the MSW section. Industrial wastes may contain toxic metals and compounds.

Significance. The Industrial Solid Waste Survey[35] determined several industrial waste streams of concern in Washington, including, among others:

- Sludges from the pulp and paper industry;
- Fly and bottom ash from boilers and furnaces of the lumber and wood products industry; and
- Brine muds from the chemical and allied products industry.

Historically, most of these wastes have been handled onsite where their environmental impacts are unknown.

Many industrial wastes are used as inputs to other processes, such as cement kilns. Private brokers often arrange such material transactions. Because of the huge volumes of these diversions, this activity greatly reduces the wastes needing management. However, these flows may contain hazardous components.

Tracking Systems. Ecology conducts limited tracking of emissions and discharges at pulp mills, aluminum smelters, and oil refineries, through reporting requirements and regulations imposed on these industries. However, because the reporting requirements are material-specific, little is known about the total waste flows generated by even these regulated industries. Limited but dated information is provided in the Industrial Solid Waste Survey completed in 1992.

Moderate Risk Waste

Sources and Composition. Moderate Risk Waste refers to used oil, paint, lead-acid batteries, and other chemicals generated by households (as Household Hazardous Waste, HHW) or businesses (as Conditionally Exempt Small Quantity Generator, CESQG, waste). Permanent facilities and temporary events (e.g., a mobile collection facility, such as the Wastemobile in King County) collect MRW wastes for reuse, recycling, or safe disposal.

Quantity and Inherent Hazard. In the year 2000, facilities and events collected 10,000 tons of MRW.[36] The most prevalent materials were used oil, paint, lead-acid batteries, and flammable liquids. These and other collected materials contain a variety of

[35] The *Industrial Solid Waste Survey Task 2 Report: Industrial Wastes of Concern in Washington*, was prepared for the Department of Ecology by Synergic Resources Corporation, Booz-Allen and Hamilton, and GBB. It was completed in 1993.
[36] As reported in *Solid Waste in Washington State*, Tenth Annual Status Report, published by Ecology's SWFA program.

hazardous substances that, if not properly treated, could pose risk to human and environmental health.

Significance. Of particular concern are the quantities of MRW that are not collected for proper treatment. Uncollected MRW may be disposed down storm drains or sewers, on site, or at un-permitted facilities. In addition, many thousand tons of MRW are improperly disposed annually in Municipal Solid Waste (over 4,000 from businesses in Seattle alone, as mentioned in the MSW section, above). Variable management systems can lead to less desirable disposal practices, affecting the environment.

Tracking Systems. Local governments that operate MRW collection programs are required to submit annual reporting forms, and response is usually high. In contrast, a dispersed network of private facilities (usually auto service centers and parts stores) that collect MRW, especially used oil, are not required to report the quantities or type of MRW they collect. However, the biggest gap in knowledge of MRW is the quantity and characterization of the large quantities of MRW that are not collected for proper management.

Biosolids

Sources and Composition. Biosolids are one of the two primary end products of the wastewater treatment process (the other being treated water effluent). Biosolids are primarily composed of the solid, organic component of domestic (residential) and industrial sanitary wastewater streams destined for treatment at Publicly Owned Treatment Works through discharge to a sewer system. In addition to the organic component, a variety of chemical and other substances (e.g., plastics) are regularly introduced to the waste stream from the following sources:

- industrial dischargers, which can, subject to a variety of regulatory conditions, discharge liquid chemical wastes to sewers in addition to their sanitary waste;
- households, which can and do introduce a variety of chemical wastes to their otherwise sanitary flow, such as unwanted liquid household cleaners;
- storm water, which, when a jurisdiction operates combined storm and sanitary sewers, contains a mixture of substances washed off roads, yards, and other surfaces; and
- pipes, which, during use, can leach the metals they contain.

Section 503 of the federal Clean Water Act stipulates a set of material attributes that biosolids must meet. The characteristics include the concentrations of nine metals (arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc), as well as pathogens and vector attraction (such as rodents and flies). EPA developed the 503 standards with a particular focus on enabling the safe application of biosolids material to land.

Quantity and Inherent Hazard. Biosolids production data obtained from the Department of Ecology's Biosolids Data Management System (BDMS) indicates that 87,717 tons of biosolids were produced in the state in 2000.[37] This data source also

[37] Using a calculation followed by the World Resources Institute, total estimated biosolids production for 2000 would be expected to be approximately 360,000 dry tons. WRI estimates production of 56 kg of biosolids/year/person. For Washington state, this would translate to 56 kg x 5,900,000 people in WA x (2.2 lbs/kg) / 2000 lbs/ton = 360,000 tons.

provides sampling data, in the form of concentrations, for the nine metals identified in the 503 regulations. Combining the metals concentration data with total production volumes does enable estimating the annual mass loading of the metals. According to the BDMS 2000 data, a substantial portion (47%) of Washington State biosolids production is land-applied – essentially used as a soil amendment – on agricultural and forested lands.[38] The rest are landfilled, incinerated, or sent offsite for management. Land application, however, introduces the potential for accumulation on land of and/or human exposure to any toxic chemical constituents contained in the material. From a safety perspective, key areas that require effective management include:

- pretreatment management of industrial wastewaters to limit metals and toxic organic chemical content;
- solids conditioning and handling to reduce pathogens and limit vector attraction; and
- land application methods that protect against nutrient runoff to surface water infiltration to groundwater.

Significance. Biosolids are subject to some chemical composition variability, although the 503 standards have been designed to address those constituents of current, known, and accepted potential risk. This variability results from the diffuse and diverse nature of dischargers to sewer systems and the practical constraints on reliably limiting material placed down the sanitary or storm drains from, for example, individual residential units and small businesses. On the solid versus the wet side of the operation, municipal wastewater treatment facilities are typically designed to focus on debris, grease, and oil removal; solids conditioning and pathogen control; and dewatering. The plants are typically not designed to treat wastewaters for entrained chemical constituents, reflecting in part the technical and economic constraints of treating high-volume wastewaters for low chemical concentrations. In this context, chemical substances, once introduced into sanitary sewers, are typically poor candidates for later treatment and are difficult to identify and track reliably. The focus, therefore, for avoiding undesirable chemical substance levels, is on preventing chemical introduction to the sewer system.

Recent studies have identified "biologically active compounds" (e.g., antibiotic medicines and hormones such as birth control pills) introduced to the sewer system as an area for further research.[39] These studies indicate the compounds do pass through the treatment process at detectable levels and therefore hold the potential to interact with the receiving environment. This study, however, focused on wastewater effluent and provided no indication of the extent to which these biologically active compounds are present in biosolids.

Tracking Systems. The Washington State Department of Ecology uses the Biosolids Data Management System (BDMS) to track annual biosolids production-related information. The U.S. Environmental Protection Agency prepared BDMS for use by states and other jurisdictions as a way to develop a consistent and efficient means to track biosolids information. The BDMS, as implemented by the Department of Ecology, automates biosolids production information collected from annual reports submitted by wastewater utilities throughout the state. The data system contains information on the total production of biosolids by individual utility. The system further contains information

[38] Since the primary constituent of biosolids is the solid, organic material resulting from human excreta, land application, when performed safely, is generally considered as the "highest and best use" of the material.
[39] See, for example, Kolpin, D.W. et al., Environ. Sci. Technol. 2002, 36, 1202-1211.

on the concentrations of the nine metals regulated under 40 CFR Part 503 in the form of sampling data produced by the utilities. Utilities also indicate the disposition method(s) (e.g., land application) for the biosolids produced during the year. Since 1998, Ecology has increased efforts to input and quality assure the data in this system. The resulting quality assured data set can support reporting on monitoring trends in overall biosolids production, the mix of disposition methods utilized, and variation in metals concentrations and mass loading. By synthesizing information on these three issues, Ecology can measure mass loading risk as well as potential impact to the environment. Ecology is currently using this data set to estimate the mass loading of mercury in support of the State's Mercury Action Plan.

OTHER MATERIAL FLOWS

Sources and Composition. Many non-product outputs from Washington's economy are not tracked under SWFA and HWTR's current programs. On a general level, these outputs include:

- Emissions to air (other than those tracked under TRI reporting);
- Discharges to water (other than those already tracked)
- Materials that are dissipated into the environment (such as fertilizers);
- Product degradation (off-gassing and wear);
- Onsite disposal; and
- Other unreported wastes disposed, leaked, or applied to land, air, or water.

Each economic actor sector is responsible for some material flow not currently tracked by SWFA or HWTR. For example, the residential sector releases significant quantities of CO_2 through vehicle use and water pollutants through pesticide applications. The construction sector displaces millions of tons of rock and soil. Dredging operations deposit hundreds of thousands of tons of sediments in Puget Sound.

Quantity and Inherent Hazard. It is impossible to know all non-product output flows. Estimates of major material flows in this category, most notably carbon dioxide (CO_2) emissions and earth-moving materials, were presented in section 2. The quantity of CO_2 emissions alone is by weight over 10 times the weight of disposed MSW. Other flows are similarly larger than the wastes currently tracked by SWFA and HWTR (see Table 2-1 for detailed estimates). Others, such as pollutants associated with fossil fuel burning in vehicles, may have significant, although not always acute, human health impacts.

Significance. Some flows in this category have marginal impact on resource depletion and have few toxic environmental or human impacts. For example, earth-moving has few such effects, although its impact on land use may affect wildlife. Others have very broad implications, particularly greenhouse gas emissions, which contribute to global warming. Global warming is expected to raise sea level and change precipitation and other local climate conditions.[40] Setting management priorities regarding each of these flows for HWTR or SWFA programs is beyond the scope of this project, though Table 3 addresses several of these other flows and provides additional characterizations of significance.

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[40] For of the mechanics and potential impacts of global warming, see the EPA's global warming web site, *http://www.epa.gov/globalwarming/*

Tracking Systems. Other local, state, or national agencies have information available to help estimate or track these flows. For example, the Washington State Office of Community, Trade and Economic Development published a report, *Greenhouse Gas Emission in Washington State*, and the Washington State Department of Agriculture tracks fertilizer distribution. Where information specific to Washington State is not available, unit-based standards developed by organizations such as the World Resource Institute (WRI) can be combined with Washington data to estimate material flows. As noted in section 2, however, such estimation techniques are not rigorous or detailed enough to support annual trend analysis or specific policy decisions.

4. Conclusion

A central tenet of Ecology's Beyond Waste vision is that what is now considered waste will in the future be considered a resource. In moving towards this vision, Ecology, its partner agencies, stakeholders, and the public will all need to be actively involved. Likely, each "economic actor" will need to consider its individual material use and waste generation behaviors.

In this paper, the consultant has taken the first step down this path – by presenting an overview and characterization of the waste and material flows in Washington, and a conceptual model to describe the processes and economic actor sectors that handle, use, and generate them. This process, and the information contained in this report, set the stage for an assessment of various tools to influence waste generation. By considering what wastes were generated by which economic actor sectors, what trends were likely to affect waste generation, and what tools were available, the consultant identified a set of highly promising initiatives. Consultant Team Issue Paper #2 describes this process in more detail, and Consultant Team Issue Papers #3-5 present action plans for achieving the Beyond Waste vision as it pertains to each of the three initiatives.

In addition, the development of the conceptual model – the materials flow framework – also helped identify gaps in Ecology's current systems of waste tracking. The consultant identified such gaps by using this model to think broadly about the range of wastes and materials in Washington, by identifying particularly large or toxic material flows, and by studying Ecology's current tracking systems. Consultant Team Issue Paper #7 presents the results of this analysis, as well as recommended improvements – and an entirely new approach – to waste and materials tracking in Washington.

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Appendix A: Methodology for Calculating Order-of-Magnitude Estimates of Material Flows

EMISSIONS

- **CO_2** was the interpolated for the year 2000 based on the projections of the Washington State office of Community, Trade and Economic Development's report, "Greenhouse Gas Emission in Washington State", available on the Energy Policy Division's web site, *www.energy.cted.wa.gov/papers/wa-ghg99.htm*.
- **Other gasses** were estimated on a national level by the World Resources Institute (WRI),[41] and scaled to Washington on a per-capita basis.

EARTH-MOVING

- **Earth-moving** was estimated on a national level by the WRI and scaled to Washington based on Washington's share of the Gross Domestic Product.

EXTRACTION WASTES

- **Coal overburden** was estimated based on the actual quantity of coal produced from strip mines in Washington in 2000, as reported annually in *Washington Geology*, a publication of the Washington State Department of Natural Resources. An overburden ratio (4.8) used by WRI was then applied to this total to estimate total overburden.
- **Gold mining wastes** were based on the actual quantity of ore processed less the amount of gold produced in Washington in 2000, as published in *Washington Geology*, a publication of the Washington State Department of Natural Resources.
- **Other mining** was estimated based on the actual quantities of sand, gravel, stone, and clay produced from in Washington in 2000, as reported annually in *Washington Geology*, a publication of the Washington State Department of Natural Resources. Overburden and gangue ratios used by WRI were then applied to these totals to estimate other mining wastes.
- **Ag losses (crop wastes)** was estimated on a national level by WRI. Their estimate was scaled to Washington based on Washington's share of the nation's farmland.
- **Ag losses (unharvested food)** was estimated on a national level by WRI. Their estimate was scaled to Washington based on Washington's share of the nation's farmland.

[41] World Resources Institute. *The Weight of Nations: Material Outflows from Industrial Economies:* Washington, DC: WRI, 2000.

- **Soil erosion** was estimated on a national level by the Natural Resources Conservation Service, a division of the USDA. Their estimate was scaled to Washington based on Washington's share of the nation's cropland.
- **Forestry Slash** was estimated on a national level by WRI. Their estimate was scaled to Washington based on Washington's share of the nation's forestry industry (as measured by employment).

OTHER WASTE AND MATERIAL FLOWS

- **Dredging** material was reported in the *Dredged Material Management Program Biennial report,* March 2002, published by the US Army Corps of Engineers, the Washington State Department of Natural Resources, the Washington State Department of Ecology, and EPA Region 10.
- **Manures** were estimated by considering the total number of dairy cows, beef cows, other cows, and pigs in Washington, as reported by the National Agricultural Statistics Service, and the average quantity of manure per animal, as studied by the University of Guelph in Ontario, Canada.
- **Fertilizers** was estimated on a national level by WRI. Their estimate was scaled to Washington based on Washington's share of the nation's farmland.
- **Sand, salt, slag, and ash spread on roads** was estimated on a national level by WRI. Their estimate was scaled to Washington on a per-capita basis.
- **Untracked biosolids.** All solid human excreta were estimated on a per-capita and national basis by WRI, using dry weight. A dry-weight estimate for Washington was then calculated by considering the population of Washington. The estimate for untracked biosolids was calculated by subtracting the dry-weight quantity of biosolids recorded by Ecology in 2000 from the statewide estimate of all solid human excreta produced.
- **Vehicle tire wear** was estimated on a national level by the World Resources Institute (WRI), and scaled to Washington on a per-capita basis.
- **Other materials dissipated to land** was estimated on a national level by the World Resources Institute (WRI), and scaled to Washington on a per-capita basis.
- **Other materials dissipated to water** was estimated on a national level by the World Resources Institute (WRI), and scaled to Washington on a per-capita basis.

Appendix B: The Vigilance Index

The Vigilance Index indicates the degree to which a material, product, or waste flow, or the individual chemical substances contained within, are of high concern because they require special (vigilant) management efforts to ensure their production, handling, use, and/or disposition occur within the boundaries of currently accepted environmental and human health risk. The Index is designed to acknowledge that, although such materials can be created, used, and disposed within the bounds of acceptable risk, their inherent hazard creates the need for relatively expensive and complex management efforts susceptible to either inadvertent mistakes or deliberate avoidance. From a cost to society and precautionary standpoint, flows that receive a high vigilance rating are important targets for elimination as products and/or waste streams.

The Index level assigned to individual items in Table 2 and Table 3 primarily reflects the stringency of current regulations that apply to the flow. For example, Dangerous Wastes are subject to relatively very stringent handling and management requirements. These requirements are very detailed, complex, impose substantial costs on generators, and require the maintenance of a costly compliance assurance infrastructure to ensure they are met. As a result, Dangerous Wastes receive a high vigilance rating. In certain instances, a flow currently may not be subject to stringent (or for that matter any) management requirements even as it contains materials that, in other contexts, are subject to stringent management. In such cases, the presence in the flow of a material of concern drives a higher vigilance rating than would otherwise be assigned on the basis of existing management requirements.

A further dimension of the Index relates to the potential for variability in the management efforts typically undertaken for the flow. For example, asbestos, as one of a handful of known human carcinogens, is subject to an array of regulatory requirements designed to manage risk during removal and disposal activities. Because asbestos is associated with diverse, diffuse, and often small sources (e.g., residential insulation and other building materials, car brake linings) it is subject to high variability in the type of management it actually receives (e.g., everything from fully certified asbestos abatement contractors operating in full compliance with federal and state requirements to unprotected homeowners improperly dumping the material at municipal solid waste transfer stations). Asbestos and asbestos containing materials would receive a high Vigilance Index rating due to their high inherent hazard and the potential for them to receive less than desirable management.

Overall, the Index is designed to provide insight into those flows that have either been identified as a cause for concern and therefore are subject to stringent management requirements or current evidence suggests they have the future potential to be subject to such requirements (e.g., biologically active compounds present in sanitary wastewater). There also are certain instances where management requirements are tied in part or whole to the flow volume and/or characteristics of the party associated with the flow. For example, Large Quantity Dangerous Waste Generators (LQGs) are subject to relatively strict dangerous waste management requirements, while Small Quantity Generators (SQGs), are subject to reduced requirements even though the flow (dangerous waste) is identical from an inherent hazard standpoint and the preferred management is identical to that required for LQGs. This discrepancy may be due to a combination of factors, including lower quantities of generated waste producing less exposure potential and the

practical and economic constraints of regulating small, diffuse sources. In these instances, the smaller flows are considered relatively high on the Index because they contain materials known to be problematic and, due to a complex array of diffuse, diverse, small sources and less stringent management requirements, are subject to substantial variability in their management.

Appendix C: Overview of Dangerous Waste Generation and Management

NOTE: The following discussion expands upon an earlier discussion found in Section 3 of this report. All findings in this report write-up are based on calendar year 2000 data stored on the Washington Department of Ecology's Hazardous Waste Information Management System (HWIMSy).

DANGEROUS WASTE

Washington State Dangerous Waste rules require all establishments generating Dangerous Wastes (irrespective of quantity) to notify the Department of Ecology of this activity and receive and maintain a Dangerous Waste identification number. Dangerous Waste reporting and management requirements for generators vary depending on the volume of generation. Large Quantity and Medium Quantity Generators are subject to onsite management and handling requirements, must, if they use off-site waste services, manifest their waste to permitted hazardous waste Treatment, Storage, Disposal, or Recycling facilities for management, and must annually report their generation and management volumes and activities to the Department of Ecology. Small Quantity Generators (SQGs) are subject to less stringent handling and management requirements (e.g., they can dispose of their waste at permitted solid waste landfills rather than permitted hazardous waste landfills) and are not required to report their Dangerous Waste activity and volumes to Ecology, although they must verify their generator status annually.

Sources and Composition. Dangerous Waste consists of non-product outputs generated during product production and service delivery activities. These waste materials, which are regulated from "cradle to grave" under the federal Resource Conservation and Recovery Act (RCRA) and Washington State Dangerous Waste rules, come in a variety of forms including inorganic liquids (e.g., aqueous acid waste), organic liquids (e.g., solvent-water solutions), inorganic solids (e.g., reactive cyanide salts/chemicals), organic solids (e.g., solid resins), inorganic sludges (e.g., plating sludge with cyanides), organic sludges (e.g., still bottoms of halogenated solvents), and, to a more limited extent, inorganic and organic gases.

KEY INDUSTRIES

The Department of Ecology's Dangerous Waste data system (HWIMSy) indicates that in calendar year 2000 there were 617 active Large Quantity Generators and 797 active Medium Quantity Generators. Large and Medium Quantity Generator industry types that account for the majority of Dangerous Waste generation in the State of Washington include the primary metals industries (SIC-33), chemicals and allied products (SIC-28), aerospace (SIC-373), petroleum refining (SIC-29), government operations, including military installations (SICs-91-97), electrical and electronic equipment (SIC-36), and services (SICs-70-89). By volume, various types of water and air pollution control activities and intermittent process or equipment decommissioning or maintenance are the predominant sources of Dangerous Waste from these industries.

HWIMSy indicates that, in calendar year 2000, there were 3,354 active Small Quantity Generators. SQGs are typically associated with small scale vehicle maintenance operations, metal fabrication and finishing operations, printers and photographic finishers, pesticide users and applicators, laboratories, and construction operations. In general, various types of cleaning operations (e.g., dip rinsing) are the typical source of SQG Dangerous Waste with various forms of cleaning materials (e.g., organic solvents) then being the typical form of waste.

Quantity and Inherent Hazard of Dangerous Wastes. Dangerous Wastes, by definition, represent materials deemed to be of very high environmental and public health concern if handled inconsistently with federal and state regulatory requirements. Ecology's HWIMSy data system indicates that 186,500 tons of Dangerous Waste were "generated" in the state[42] in the calendar year 2000. Of this total, 171,300 tons were classified as "recurrent" waste (those that are directly produced by production or service processes or result from the treatment of hazardous or non-hazardous waste) and 15,200 tons were classified as "non-recurrent" waste (those associated with spill cleanups, one-time equipment decommissioning, or other remedial cleanup). The recurrent waste total excludes waste generated by the United States Department of Energy's Hanford Facility and permitted, commercial TSDRs.[43]

RECURRENT, NON-WASTEWATER, AND NON-MIXED RADIOACTIVE WASTES PROFILE

The HWIMSy data system indicates that 99,814 tons of primary, recurrent, non-wastewater, and non-mixed radioactive wastes were generated during 2000.[44] Primary metals industrial operations (SIC-33) accounted for over half of this total (about 60,000 tons), with chemicals and allied products (SIC-28) (about 17,000 tons) and aerospace (SIC-373) (about 8,000 tons) representing the other major industrial categories of Dangerous Waste Generation. Petroleum refining, government agencies (including military installations), general services, electrical and electronic equipment, and wholesale trade represent an important second tier of generators accounting individually for between 1 and 3 percent of overall generation.

Dangerous Waste source data included in the HWIMSy data system indicate that various forms of pollution control activity are the predominant sources of Dangerous Waste generation activity. Wastes from sludge dewatering (19,500 tons), product distillation (16,600 tons), air pollution control devices (12,800 tons), and wastewater

[42] Dangerous Waste reports indicate wastes managed by generators during the reporting year. Technically, the data do not represent calendar year generation because waste generated previously but managed during the reporting year are captured and waste generated during the reporting year but managed in future years are not captured.

[43] Note that Ecology typically removes Hanford from waste generation totals given the unique nature of the facility, its wastes, and related clean-up activities and TSDR wastes because these wastes typically result from the management of other Dangerous Wastes received from off site for treatment and are thus deemed "secondary" generation.

[44] Ecology typically looks to discern recurrent waste generation by removing volumes associated with hazardous wastewaters - those flagged in the HWIMSy data system as Treatment by Generator or Permit by Rule - and mixed radioactive wastes. Wastewaters, because they often reflect high volumes of liquid with relatively low concentrations of Dangerous Waste constituents, can distort generation totals, and mixed radioactive wastes represent a unique waste stream subject to regulation under the Nuclear Regulatory Act.

treatment (3,000 tons) sources account for 53 percent of the primary, recurrent, non-wastewater, non-mixed radioactive wastes reported as generated in 2000. These data send a strong message in terms of Ecology's Beyond Waste Vision: if Ecology is to successfully implement the Beyond Waste vision, the agency will need to emphasize thinking "up the pipe" and maximize cross-program coordination, since much of the Dangerous Waste is generated by processes subject to regulation under the Clean Air and/or Clean Water Acts or results from pollution control efforts associated with their regulations.

A substantial portion (27,700 tons or approximately 28 percent) of the waste was reported associated with highly generic sources of waste: Source Code A59 – Other Production-Derived One-Time and Intermittent Processes (9,300 tons); Source Code A99 – Other (8,500 tons); Source Code A56 – Discontinue Use of Process Equipment (7,600 tons); and Source Code A09 – Clean Out Process Equipment (2,300 tons). These data provide very limited ability to understand the specific processes associated with this generation quantity. Approximately 5 percent (5,300 tons) of the waste was associated with discreet cleaning and degreasing sources such as stripping, dip rinsing, acid cleaning, and vapor degreasing, while approximately 4 percent (4,300 tons) was associated with discreet surface preparation and finishing sources such as painting, etching, electroplating, and heat treating. Seventy-nine percent of the waste generation was associated with six forms of waste: Form Code B319 – Other Inorganic Liquids (19,300 tons); Form Code B511 – Air Pollution Control Device Sludge (19,300 tons); Form Code B606 – Resins, Tars, and Tarry Sludge (15,600 tons); Form Code B409 – Other Nonhalogenated Organic Solids (11,800 tons); Form Code B404 – Spent Carbon (9,600 tons); and Form Code 316 – Other Metal Salts/Chemicals (3,600 tons).

PERMIT BY RULE, TREATMENT BY GENERATOR, AND MIXED RADIOACTIVE WASTES PROFILE

Permit by Rule (PBR), Treatment by Generator (TBG), and Mixed Radioactive wastes totaled 22,619, 16,745, and 33,992 tons, respectively in 2000.[45] Six generators reported generating PBR wastes, with the Boeing Renton site accounting for 20,732 tons of the 22,619 ton total. Seventy-seven generators reported generating TBG wastes, with 71 percent (11,850 tons) accounted for by four generators: JH Baxter & Co Arlington; NORTHWEST ALLOYS INC; Framatome ANP Richland Inc.; and Joseph Simon & Sons Co. Mixed radioactive wastes were reported by 14 generators, with two – Framatome ANP Richland Inc. (25,447 tons) and USN PSNS Bremerton (8,530 tons) – accounting for 99 percent of the reported waste.

Significance. As mentioned above, Dangerous Wastes, by definition, represent materials deemed to be of very high environmental and public health concern if handled inconsistently with federal and state regulatory requirements. Although such materials can be created, routed to reuse or recycling, and/or disposed within the current bounds of acceptable risk, their high inherent hazard creates the need for relatively expensive and complex management efforts subject to either deliberate avoidance or inadvertent mistakes. Certain dangerous wastes are also subject to the potential for variability in the management efforts typically undertaken for them. This occurs because, under federal

[45] Note that these three totals plus the primary, recurrent total of 99,814 tons exceed the overall recurrent waste estimate of 171,300 tons by 1,870 tons. This discrepancy likely results from certain waste volumes being associated with more than one of the indicators – PBR, TBG, Mixed – used to isolate these volumes in the data set.

and state dangerous waste regulatory requirements, the nature of management requirements are tied in part or whole to the volume of waste generated and/or disposition methods selected.

Small Quantity Generators and Wastewaters

Small Quantity Generators are subject to reduced management requirements even though the waste material is identical from an inherent hazard standpoint and the preferred management is identical to that required for Medium and Large Quantity Generators. In this case, the regulatory system has identified these waste types as problematic. However, due to a combination of factors including lower quantities producing less exposure potential and the practical and economic constraints on regulating small, diffuse sources, SQGs have less stringent management and reporting requirements. Wastewaters containing dangerous wastes can be disposed through public wastewater treatment systems subject to a different type of management requirements largely imposed by Clean Water Act pretreatment and biosolids quality standards.

From a precautionary standpoint, the identified need for intensive and complex management coupled with the potential for variable management not always consistent with preferred management practices, makes dangerous wastes a high priority for elimination efforts

Tracking Systems. The Washington State Department of Ecology has used the Hazardous Waste Information Management System (HWIMSy) since 1995 to track annual dangerous waste generation and management activities. HWIMSy provides automation for data received annually from dangerous waste generators and permitted treatment, storage, disposal, and recycling (TSDR) facilities via the Dangerous Waste Annual Report. The data system primarily contains two general categories of dangerous waste-related information: dangerous waste generator activity data (from the Generation and Management Form); and TSDR activity data (from the Waste Received Form). Dangerous waste generator activity data includes the types, forms, sources, and volumes of dangerous waste moved to management during the reporting year and indicate the location and type of management the waste received. TSDR activity data indicate the type, form, and quantity of dangerous waste individual TSDRs received for management during the reporting year and identify the type of management these wastes received. In addition to these two primary data pools, HWIMSy also contains limited information on dangerous waste generators that have indicated through an annual notification process that they are Small Quantity Generators and, therefore, are not required to report waste generation activity.