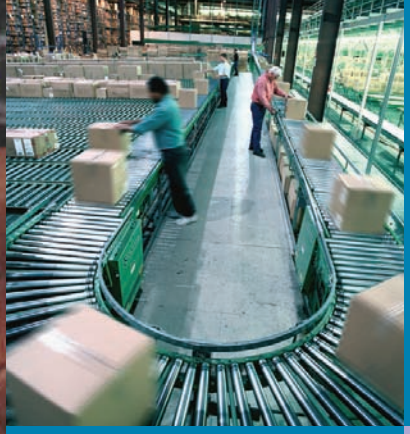

The Lean and Environment Toolkit

- Improve Environmental Results
- Reduce Business Costs and Risk
- Identify and Eliminate Waste

www.epa.gov/lean

Toolkit Format and Icons

The toolkit uses icons in the page margins to help you find and follow important information in each chapter.

Key Point Identifies an **important point** to remember

Key Term Defines an **important term** or concept

New Tool Presents a **technique or resource** that helps capture, communicate, or apply new knowledge

How-to Steps Describes **sequenced actions** to implement a tool

Chapters also include one or more "**To Consider**" text boxes that contain questions to help you explore how the information relates to your organization.

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Appendices

Preface

This *Lean and Environment Toolkit* assembles practical experience collected by the U.S. Environmental Protection Agency (EPA) from a group of partner companies and organizations that have experience with coordinating Lean implementation and environmental management. The toolkit builds on work conducted and research sponsored by EPA's Lean Manufacturing and Environment Initiative (see http://www.epa.gov/lean).

The EPA's intent in developing this toolkit is to enable Lean practitioners to improve both their business performance and their environmental performance by identifying and eliminating environmental wastes at their organizations. The toolkit offers practical strategies and tools for integrating environmental considerations into Lean initiatives in ways that support Lean's focus on the elimination of waste and non-value added activity.

This is the second iteration of the Toolkit. EPA welcomes your comments and reflections on this document, as well as other ideas you have for Lean and environment strategies, tools, and resources which can be incorporated in future versions of the toolkit. Please contact EPA to share your experiences with Lean and the environment and/or to discuss partnership opportunities by using the form found at http://www.epa.gov/lean/auxfiles/contact.htm.

Acknowledgments

The U.S. Environmental Protection Agency is very grateful for the invaluable assistance of its partners in developing this toolkit. EPA's partners shared their experiences, tools, and techniques for integrating Lean and environmental management, and worked collaboratively with EPA to develop, test, and refine the content of this toolkit.

EPA's Lean and Environment partners include: Baxter International, Chicago Manufacturing Center, CONNSTEP, HNI Corporation, Robins Air Force Base, Rockwell Collins, and the U.S. Army Materiel Command. Participating Offices at EPA include: the National Center for Environmental Innovation; the Office of Pollution Prevention and Toxics; and the Office of Solid Waste.

In addition to these organizational partners, this toolkit has benefited from the collective expertise and ideas of many individuals. In particular, EPA would like to thank the following individuals for their thoughtful contributions:

Pat Bartholomew of Baxter International

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CHAPTER 1

Introduction: Getting Started with Lean & Environment

Chapter Contents

Purpose of This Toolkit

*The **Lean and Environment Toolkit** offers practical strategies and techniques to Lean implementers about how to improve Lean results—waste elimination, quality enhancement, and delivery of value to customers—while achieving environmental performance goals.* The toolkit also provides tools to help your organization get better environmental performance from Lean efforts on the shop floor.

Benefits of Coordinating Lean & Environment

- ✓ Reduce costs
- ✓ Improve process flow and reduce lead times
- ✓ Lower regulatory non-compliance risk
- ✓ Meet customer expectations
- ✓ Improve environmental quality
- ✓ Improve employee morale and commitment

The "Lean" methods discussed in this Toolkit are organizational improvement methods pioneered in the Toyota Production System. *Lean production* and *Lean manufacturing* refer to a customer-focused business model and collection of methods that focuses on the elimination of waste (non-value added activity) while delivering quality products on time and at a low cost. The toolkit assumes that you are familiar with Lean methods and their implementation. For those who want to learn more about Lean methods discussed in the toolkit, see Appendix A.

Key Questions Addressed by the Toolkit

Lean works well when it focuses on identifying and eliminating non-value added activity. Environmental improvement efforts that have potential to distract Lean efforts from this prime focus will likely not get much traction. By contrast, this toolkit contains strategies and techniques that can seamlessly enable Lean practitioners to easily identify environmental wastes and improvement opportunities alongside the myriad other wastes and improvement opportunities uncovered by Lean. To accomplish this, the toolkit aims to answer the following questions:

What is environmental waste?

Environmental waste is an unnecessary or excess use of resources or a substance released to the air, water, or land that could harm human health or the environment. Environmental wastes can occur when companies use resources to provide products or services to customers, and/or when customers use and dispose of products. *Chapter 2 defines and provides examples of environmental waste.*

Why should I identify environmental waste in my processes?

Environmental wastes do not add value to the customer. Environmental wastes can also directly affect production flow, time, quality, and cost—making them ripe targets for Lean initiatives. In many cases, the costs associated with pollution and wasted energy, water, and raw materials can be significant. *This chapter (Chapter 1) discusses the business case for eliminating environmental waste.*

How will I know when I see environmental waste?

Some environmental wastes are easy to see. Containers of solid and hazardous waste are visual indications of environmental waste. Health and environmental risks posed by certain chemicals or materials can be more difficult to see, although they can represent costly non-value added aspects of a process or product. *Chapter 2 provides examples of environmental wastes and describes organizational strategies that will make it easier to know when you see them.*

Where should I look for environmental wastes?

Environmental wastes can be found in almost any process. Processes requiring environmental permits—such as painting, metal finishing, and hazardous waste management processes—are often a good place to look for environmental improvement opportunities. If your organization has an environmental management system (EMS), your Environmental, Health and Safety (EHS) personnel may have already identified key environmental impacts associated with each of the organization's processes. *Chapter 3 discusses how value stream mapping (VSM) tools and techniques can be used to help Lean practitioners see environmental wastes in processes. Chapter 4 discusses how to identify and address environmental wastes during kaizen rapid improvement events.*

How do I measure the environmental impacts of a process?

Measurement of key environmental wastes associated with a process can pinpoint those wastes that are most important to track over time. For example, chemical use and hazardous waste generation may be important to measure for one process, while water use may be most important to measure for another process. *Chapter 3 discusses techniques for integrating environmental metrics into value stream maps. Appendix B includes information on environmental metrics that are often used by companies and facilities.*

Where can I find environmentally preferable alternatives to my current process?

EHS professionals in your organization may have ideas and information regarding environmentally preferable processes, equipment and materials. In addition, numerous organizations, including EPA, have developed technical assistance resources and programs to assist organizations in improving the environmental and operational performance of processes. *Chapter 4 discusses several useful resources and technical assistance networks. There are also Pollution Prevention Resources in Appendix D.*

Why Use This Toolkit

Explicit consideration of environmental goals and opportunities during Lean implementation can create significant value for an organization—helping to deliver quality products and services that customers want, when they want them. Research sponsored by EPA and others shows that environmental performance benefits typically ride the coattails of Lean efforts, yet these efforts may overlook other opportunities to reduce wastes and non-value added activity. Adding environmental considerations to Lean efforts can increase value, accelerate Lean implementation, decrease material costs, and reduce liability and the risk of compliance violations.

Business Case for Integrating Lean & Environment

1. Learn to see hidden environmental waste.
2. Enhance the effectiveness of Lean implementation.
3. Deliver what customers and employees want.

Below are three key reasons why business leaders, Lean practitioners and EHS managers have pursued efforts to coordinate Lean and environmental management activities.

1. Learn to See Hidden Environmental Waste and Hazards

Learning to see and eliminate waste is a cornerstone of Lean initiatives. There is one type of waste, however, that often goes unaddressed (or under addressed) by Lean initiatives—environmental waste. When grouped together, environmental wastes can result in huge costs to business. These costs include raw material and disposal costs, as well as costs for compliance management activities and pollution control equipment.

Lean's focus on eliminating non-value added activity is excellent at driving down the volume of material, water, energy, chemical usage, and wastes, producing important competitiveness and environmental benefits. The environmental risk and full lifecycle impacts that materials and chemicals pose to human health and the environment, however, are rarely considered during Lean implementation. Learning to see environmental wastes during Lean efforts can open significant business improvement opportunities, further strengthen Lean results, and improve environmental performance.

Environmental wastes are often a sign of inefficient production, and they frequently indicate opportunities for saving cost and time. The chemicals and hazardous materials used in a process often demand costly support activities, such as regulatory compliance management and reporting activities, use of personal protective equipment, and the investment, operation, and maintenance of pollution control equipment. These activities do not add value to the customer, and they can create unnecessary risks to worker health and safety.

Chemical substitution, process changes, and other strategies can reduce the need for such non-value added activities. For these reasons, learning to see and eliminate environmental wastes can greatly improve the time, quality, and cost results of Lean initiatives.

2. Enhance the Effectiveness of Lean Implementation

Explicit coordination of Lean and environmental initiatives can lead to compelling organizational and environmental improvement results. For example, Lean thinking can be applied to various environmental management processes, such as chemical and waste management. Companies have found that as much as 40 percent of their chemical supplies were going unused and directly becoming hazardous waste as they expired on the shelf or became obsolete. Using Lean principles to improve chemical and waste management processes can have big pay-offs for environmental performance and bottom-line results.

Case Study: Lockheed Martin Corporation

Lockheed Martin Corporation, the world's largest defense contractor, has been implementing Lean techniques corporate-wide since the late 1990s. Lockheed Martin's Manassas plant conducted improvement events to apply Lean thinking to its chemical and waste management activities because a significant amount of warehoused chemicals were going directly to the hazardous waste stream without ever being used, expired on-shelf, or were no longer used for research or production. Lockheed Martin sought to move toward a just-in-time chemical management system, with chemicals delivered three times a week in "right-sized" containers to meet real-time demand. The Lean events reduced chemical inventories, freed capital tied up in inventory, increased chemical inventory turns and chemical utilization rates, and eliminated the chemical warehouse and chemicals expiring on the shelf.

Proactive Lean and environment coordination can also anticipate and ease environmental constraints to leaning "monument" processes, thereby enabling large performance gains. Monuments are production processes or process steps that have large equipment and/or other physical or environmental regulatory constraints that make them very difficult or costly to move, which can complicate Lean efforts. Typical monuments include painting and metal finishing processes.

Making changes to monument processes can require approval or permits from environmental regulatory agencies, as well as special work practices or control measures, all of which can be difficult to accomplish within rapid timeframes. EHS personnel can help to identify environmentally friendly process alternatives, and ensure that process changes can be made as quickly as possible.

Case Study: Apollo Hardwoods

Apollo Hardwoods used Lean methods to manufacture custom "cut-to-size" cherry plywood for cabinetry. The company's founders and investors discovered that a "right-sized" veneering process would require less expensive equipment, use a wider variety of logs, and produce less wood scrap, without compromising product quality. The company sought to find a veneering process that would also address product quality, flow time, and cost. Since such a process did not exist, Apollo Hardwoods recruited a team to develop a Lean veneer slicing and drying process and associated equipment using the pre-production planning (3P) method. The Lean veneer manufacturing process incorporated one-piece flow cells that eliminated the piling of inventory in between steps. The "right-sized" equipment requires less capital than conventional machinery (or "monuments"), uses less energy, fits into small production cells, and allows Apollo Hardwoods to fabricate the same amount of finished product using fewer logs and generating less wood scrap.

3. Deliver What Customers and Employees Want

Most customers who purchase products do not want to buy environmental wastes, impacts, or risk. *Companies that can deliver products and services with fewer environmental impacts have the potential to capture significant competitive advantage, provided that there are not sacrifices in time, quality, or cost.* In many markets products with superior environmental performance can attract new customers.

Explicit consideration of environmental waste in Lean initiatives can also improve the work environment for employees. Similar to ergonomic concerns, eliminating environmental hazards can reduce potential worker exposure to toxic substances and create a cleaner and safer workplace.

In addition, employees want to do the right thing. When employees take pride in their work because they believe it has broader benefits to their community and the world, there can be a substantial positive effect on organizational morale. This can empower employees and further enhance productivity.

To Consider

- How could your company benefit from improved Lean and environmental performance? (Think about time and cost savings, reduced risks and liabilities, added value to customers, etc.)
- How well coordinated are Lean and environmental management activities in your organization?
- Do EHS personnel participate in Lean events and initiatives at your company?

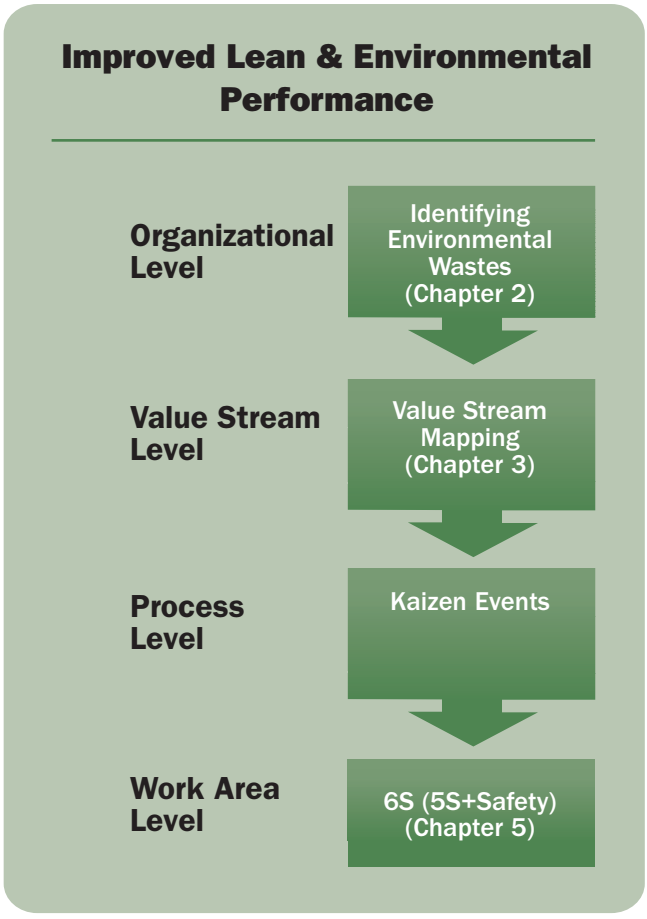
How to Use This Toolkit

This section describes the structure and organization of the *Lean and Environment Toolkit* (Version 1.0), as well as icons that are used to help you navigate the information easily. The toolkit is designed so that you can work through the full content in an ordered manner or skip to specific methods that are of most interest.

Toolkit Structure and Chapters

The toolkit is structured in chapters, each focusing on strategies, tools, and techniques to enhance the success of Lean initiatives while improving environmental performance. Chapters 2–5 focus on core Lean methods and how-to strategies for leveraging environmental considerations to enhance Lean results. The diagram below illustrates how these chapters focus on coordinating Lean and environmental activities on different organizational levels—the value stream level, the process level, and the work area level. Chapter 6 provides summary points and guidance to assist you in putting the strategies and techniques discussed in the toolkit to work in your organization.

Figure 1: Diagram of Toolkit Components



Conclusion

Summary

This toolkit provides practical strategies, tools, and techniques for incorporating environmental considerations into already existing Lean initiatives in an effort to improve Lean results and add value to your organization.

There are three key reasons why business leaders, Lean practitioners, and EHS managers pursue efforts to coordinate Lean and environmental management activities.

1. *Learning to see and eliminate hidden environmental wastes during Lean implementation can lead to more efficient production by improving the time, quality, and cost results of Lean initiatives.* Chemical substitution, process changes and other strategies can reduce the need for non-value added activities—such as regulatory compliance management and investment in pollution control equipment—that might otherwise be overlooked by Lean alone.
2. *Coordination of Lean and environmental management can facilitate more process improvement and make it easier to apply Lean to processes with environmental regulatory constraints.* EHS personnel can assist Lean implementation by anticipating and addressing environmental constraints such as the need to obtain permits, and by identifying environmentally friendly process alternatives.
3. *A significant competitive advantage can be attained by providing customers with products and services with less environmental impacts, and by improving the work environment for employees.*

Your Thoughts

Now that you have finished this chapter, reflect on what you read by answering these questions:

- What did you learn in this chapter that was particularly useful?
- Do you need any more information to fully understand the business case for identifying and eliminating environmental waste? How strong is the business case for doing this in your organization?
- What ideas do you have for helping your organization learn to see environmental wastes?

Notes:

CHAPTER 2
Identifying Environmental Wastes

Chapter Contents

Introduction to Identifying Environmental Wastes

This chapter defines environmental waste and describes strategies to encourage employees to identify and eliminate environmental waste as part of Lean efforts.

Definition of Environmental Waste

Environmental waste is any unnecessary use of resources or a substance released into the air, water, or land that could harm human health or the environment. Environmental wastes can occur when companies use resources to provide products or services to customers, and/or when customers use and dispose of products. Practically speaking, environmental wastes include:

- *Energy, water, or raw materials* consumed in excess of what is needed to meet customer needs.
- *Pollutants and material wastes* released into the environment, such as air emissions, wastewater discharges, hazardous wastes and solid wastes (trash or discarded scrap).
- *Hazardous substances* that adversely affect human health or the environment during their use in production or their presence in products.

Like other Lean wastes, environmental wastes do not add customer value. They also represent costs to the enterprise and society in general.

The Link Between Environmental Waste and Lean's Seven Deadly Wastes

The focus of Lean is on eliminating any non-value added activity, or waste, from production. Lean typically targets seven so-called deadly wastes:

1. Overproduction
2. Inventory
3. Transportation
4. Motion
5. Defects
6. Over Processing
7. Waiting

Case Study: Rejuvenation

Rejuvenation, a manufacturer of period-authentic reproduction lighting and hardware, operates on the philosophy that the reuse and improvement of old properties has environmental benefits. Using an environmental management system based on The Natural Step and Lean manufacturing, Rejuvenation has reduced its environmental wastes and increased quality and profit. Prior to Lean implementation, finished products were not inspected until the end of the line at a quality control center, causing expensive rework if mistakes were found. Through Lean events, the quality control center was eliminated, quality control became everyone's job, and customization errors are now corrected before moving on to the next process. Rejuvenation also regularly implements other Lean tools such as 5S, kaizen events, and value stream mapping.

Environmental wastes, such as hazardous materials released to the environment, are not explicitly included in the seven deadly wastes of the Toyota Production System. However, this does not mean that the deadly wastes are unrelated to the environment. In fact, *your company may have already seen large environmental gains from implementing Lean, because environmental wastes are embedded in, or related to, the seven deadly wastes.*

The table below lists environmental impacts that are associated with the deadly wastes targeted by Lean methods. By reducing these production wastes through Lean efforts, you can improve your organization's environmental performance.

Table 1: Environmental Impacts of Deadly Wastes

Waste Type	Environmental Impacts
Overproduction	• More raw materials and energy consumed in making the unnecessary products • Extra products may spoil or become obsolete requiring disposal • Extra hazardous materials used result in extra emissions, waste disposal, worker exposure, etc.
Inventory	• More packaging to store work-in-process (WIP) • Waste from deterioration or damage to stored WIP • More materials needed to replace damaged WIP • More energy used to heat, cool, and light inventory space

Table 1: Environmental Impacts of Deadly Wastes *(continued)*

Waste Type	Environmental Impacts
Transportation and Motion	• More energy use for transport • Emissions from transport • More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption • More packaging required to protect components during movement • Damage and spills during transport • Transportation of hazardous materials requires special shipping and packaging to prevent risk during accidents
Defects	• Raw materials and energy consumed in making defective products • Defective components require recycling or disposal • More space required for rework and repair, increasing energy use for heating, cooling, and lighting
Over processing	• More parts and raw materials consumed per unit of production • Unnecessary processing increases wastes, energy use, and emissions
Waiting	• Potential material spoilage or component damage causing waste • Wasted energy from heating, cooling, and lighting during production downtime

Despite these relationships between Lean "deadly wastes" and environmental wastes, Lean implementation efforts often overlook opportunities to prevent or reduce environmental wastes. *Your company can enhance its Lean performance by ensuring that environmental wastes are explicitly identified during Lean events and activities*. This can be done by extending Lean waste identification activities to consider wasted materials, pollution and other non-product outputs.

This toolkit provides you with some tools to identify and eliminate environmental waste—including some that are well hidden—and to maximize the environmental gains from Lean implementation.

To Consider

- What types of environmental performance gains has your company seen from implementing Lean methods? (For example, have you reduced chemical use in a process, generated smaller quantities of hazardous waste, or reduced vehicle travel thereby reducing exhaust emissions and fuel use?) If you don't know, how will you find out?
- Name three examples of environmental wastes you could reduce at your company. What steps could you take to eliminate those wastes?

How to "Learn to See" Environmental Waste in Your Organization

Overview of Organizational Strategies

As Lean leaders know, people are the key to successful Lean implementation. In much the same way, organizational culture is an important aspect of effective integration of environmental, health, and safety objectives into Lean improvement efforts. While each organization has different needs, several organizational strategies will help to accomplish your company's Lean and environment efforts.

1. Add environmental metrics to Lean metrics.
2. Show management commitment and support.
3. Include environmental waste in Lean training efforts.
4. Make environmental wastes visible and simple to eliminate.
5. Recognize and reward success.

1. Add Environmental Metrics to Lean Metrics

One simple way to understand how your company's Lean efforts are affecting the environment is to add one or more environmental performance metrics to the metrics used to evaluate and track the success of Lean implementation. See the textbox below for examples of types of environmental metrics and Appendix B for a detailed list of *environmental performance metrics*.

Types of Environmental Metrics

- ✓ Scrap/Non-product Output
- ✓ Materials Use
- ✓ Hazardous Materials Use
- ✓ Energy Use
- ✓ Water Use
- ✓ Air Emissions
- ✓ Solid Waste
- ✓ Hazardous Waste
- ✓ Water Pollution/Wastewater

Using environmental metrics in Lean efforts will allow your company to document the environmental benefits that are part of Lean implementation, as well as identify targets for future improvement efforts.

2. Show Management Commitment and Support

It is important that senior management—both facility management and EHS management—at your company show their support for improved Lean and environment initiatives. While it is possible to build management support from the bottom up through pilot projects, securing top-down management commitment helps to ensure the long-term success of Lean and environment efforts. Management can show support through the following types of activities:

- Invest in Lean and environment training.
- Provide resources, tools and incentives to enable employees to succeed.
- Include Lean and environment concepts in speeches, newsletters and other communications.
- Encourage Lean managers and EHS managers to collaborate.
- Set performance goals and objectives related to Lean and environment.
- Track Lean and environment progress and hold individuals accountable for meeting those objectives.
- Recognize and reward Lean and environment accomplishments.

3. Include Environmental Waste in Lean Training Efforts

One important way to help employees learn to see environmental waste is to integrate it into general Lean training programs. Here are a few suggestions:

- Your company might want to include a section on how to identify and eliminate environmental waste in introductory Lean training presentations.
- Consider modifying Lean's seven deadly wastes to include an eighth waste—environmental waste—in training presentations and materials.

- Consider conducting a "waste walk" during Lean trainings where workers walk the shop floor and write down environmental wastes they observe.
- Develop checklists or a pocket guide with common environmental wastes to use during events and waste walks.

Two other types of Lean and environment training might be useful:

- Lean training for EHS personnel—to enable them to more effectively support Lean activities and help with identifying environmental waste; and
- Advanced environmental training—to enable employees to understand environmental and human health risks associated with materials selection and with product and process design.

Chapter 4 of this toolkit has suggestions for training Lean teams to recognize when process changes may cause potential harmful environmental impacts. In addition, EPA developed a series of Lean and Environment Training Modules that are a useful resource for designing training programs.

4. Make Environmental Wastes Visible and Simple to Eliminate

Your company can take advantage of Lean's focus on visual controls to support your company's Lean and environment efforts. Here are a few suggestions:

- Prominently display how individual production areas or departments are doing relative to targets for environmental metrics alongside Lean metrics.
- Incorporate environmental wastes into activity and production control boards, one-point lessons, and other signs about wastes on the shop floor.
- Apply 6S and mistake-proofing concepts to work areas where chemical use, chemical management, waste collection and waste management activities occur. Use colors, signs, and other visual controls to reinforce proper chemical handling and waste management and environmental procedures.

5. Recognize and Reward Success

An initial step in your company's Lean and environment journey may be to recognize what environmental gains your company has already accomplished with Lean. *Production managers and line operators may not be accustomed to receiving awards or other recognition for environmental improvements, but they will be more likely to seek additional ways to improve once they do*. Recognition can be as simple as an announcement in a company newsletter, or can be set up as a competition between production areas to achieve the greatest gains.

Your company may not always succeed with its Lean and environment efforts, so that makes it all the more important to recognize and reward successful efforts, to learn from any mistakes, and to continually try new things and work to improve your company's performance.

To Consider

- What are three things you could do to explicitly include environmental wastes in your company's Lean implementation efforts?
- What ideas do you have for involving employees at all levels of your company in efforts to identify and eliminate environmental wastes?
- What environmental goals and targets does your organization have?

Conclusion

Summary

Environmental waste is any unnecessary use of resources or a substance released into the air, water, or land that could harm human health or the environment.

Environmental wastes, although not considered one of Lean's seven deadly wastes, are embedded in or related to the wastes targeted by Lean methods. Like other Lean wastes, environmental wastes represent costs to your company. Making them an explicit target of Lean events can help your company to:

- Continually improve performance by expanding on the reduction of production wastes through Lean efforts;
- Identify and address areas of potential environmental benefits that might be overlooked by Lean alone; and
- Identity and eliminate hidden risks and wastes.

Using *environmental performance metrics* in Lean efforts enables managers to understand key areas for improvement. Types of environmental metrics include:

- Use of energy, materials and water;
- Air emissions;
- Water pollution and wastewater; and
- Hazardous waste and non-hazardous solid wastes.

Summary (continued)

There are five organizational strategies that can help to integrate Lean and environmental waste reduction efforts:

1. Add environmental metrics to the metrics considered in Lean efforts to better understand the environmental performance of production areas.
2. Show management commitment and support for improved Lean and environmental performance by holding collaborative meetings and providing resources and recognition.
3. Integrate environmental wastes into Lean training programs. This can be as simple as adding a few additional slides to a presentation or as advanced as holding a special Lean training for EHS personnel.
4. Make environmental wastes visible and simple to eliminate by using signs and other visual controls in the workplace.
5. Recognize and reward environmental success accomplished through Lean.

Your Thoughts

Now that you have finished this chapter, reflect on what you read by answering these questions:

- What did you learn in this chapter that was particularly useful?
- Do you need any more information to fully understand organizational strategies for eliminating environmental waste? Would any other tools be helpful?

Notes:

CHAPTER 3
Value Stream Mapping

Chapter Contents

Introduction to Value Stream Mapping

While the last chapter discussed how to raise awareness about environmental wastes across your organization, this chapter will show you how to target Lean improvement efforts within a product's value stream. The chapter describes ways to enhance value stream mapping to uncover hidden sources of material wastes, identify process improvement ideas, and anticipate regulatory compliance needs.

Definition of Value Stream Mapping

Value stream mapping is a Lean process-mapping method for understanding the sequence of activities and information flows used to produce a product or deliver a service. Lean practitioners use value stream mapping to:

- Identify major sources of non-value added time in a value stream;
- Envision a less wasteful future state; and
- Develop an implementation plan for future Lean activities.

The power of value stream mapping lies in walking the plant floor, talking to workers, and closely observing how a product is actually made from start to finish. See Appendix A for more information on value stream mapping.

Case Study: General Motors

General Motors has been integrating Lean manufacturing and environmental initiatives since the 1990s, including kanban, kaizen events, and value stream mapping (VSM). In a more recent effort, the company conducted a kaizen event with a key supplier to enhance the cost competitiveness and on-time delivery of steering column components. GM used VSM and Toyota's "five whys" technique and observed delays when steering column shrouds were shipped to an outside vendor for painting. Because the shrouds were only painted to cover flaws caused by the die, GM suggested improving the quality of the die and molding the part using a resin of the desired color. The supplier began using a new molding process that removed the need for the painting step. This project saved the supplier $700,000 per year, shortened lead times, and improved on-time delivery to GM.

What This Chapter Will Help You Do

This chapter will help you identify and address the following wastes that can be overlooked in value stream mapping:

- Raw materials used by processes versus materials needed for the product;
- Pollution and other environmental wastes generated in the value stream; and
- Flows of information to regulatory agencies about environmental compliance management activities.

Analyzing these flows in value streams at your company could reveal substantial opportunities to reduce costs, improve production flow, and save time, as well as improve environmental performance and the health and safety of the workplace. Early attention to environmental considerations and involvement of EHS staff when planning for future Lean improvement efforts in a value stream can also help your company address potential regulatory compliance issues, minimize delays, and avoid the need for costly rework.

How to Incorporate Environmental Considerations into Value Stream Mapping

Overview of Value Stream Mapping Opportunities

There are at least five ways to explicitly address pollution and natural resource wastes using value stream mapping.

- Use icons to identify processes with EHS opportunities.
- Record environmental data for processes in value stream maps.
- Analyze materials use versus need in a "materials line" for value stream maps.
- Expand the application of value stream mapping to natural resource flows.
- Find Lean and environment opportunities in future state value stream maps.

1. Use Icons to Identify Processes with EHS Opportunities

Some processes warrant a special focus on EHS issues because they can pose hazards to workers, have permits and other regulatory requirements, and/or represent good opportunities to reduce pollution and material costs. To raise awareness about these risks and opportunities, use a *red dot* or an *EHS icon* to identify these processes on value stream maps.

Staff with EHS expertise can help your value stream mapping team determine where to place EHS icons on value stream maps. The following textbox lists some common manufacturing processes with environmental opportunities.

10 Common Manufacturing Processes With Environmental Opportunities

1. Metal casting
2. Materials treatment
3. Metal fabrication and machining
4. Cleaning and surface preparation
5. Bonding and sealing
6. Welding
7. Metal finishing and plating
8. Painting and coating
9. Chemical and hazardous materials management
10. Waste management

It is essential for EHS staff to participate in planning for and conducting Lean events on these processes because of the potential risks of non-compliance and the potential hazards to workers. EHS staff can also bring fresh ideas and new tools to add to the solution set. Chapter 4 provides more information about how to identify and address EHS issues during kaizen events, which are rapid process improvement events.

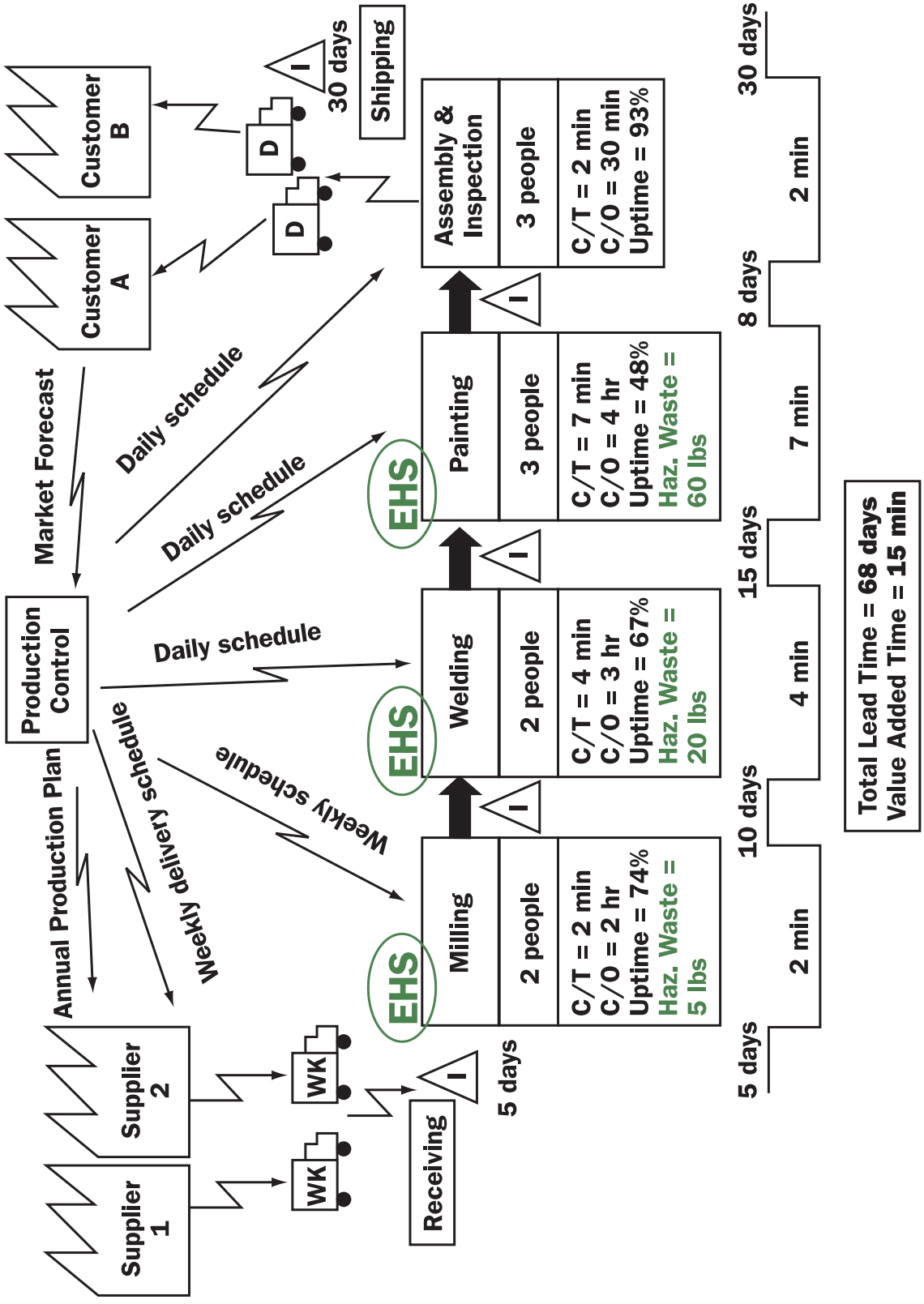
2. Record Environmental Data for Processes in Value Stream Maps

A second way to uncover environmental wastes in value stream mapping is to select one or two environmental performance metrics to measure for each process in the value stream. A list of types of environmental metrics you could use can be found on page 16; Appendix B provides more detailed information about metrics.

If your company does not already have these data available at the process level, you may need to invest additional time and/or resources to collect environmental data about the current state. For example, you could weigh the amounts of scrap and solid wastes generated by each process during a shift, or use energy meters to estimate typical energy use. *This extra investment in data collection will allow you to appropriately target Lean improvement efforts on the highest priority problems, and thereby achieve the greatest benefits.*

Figure 3 shows a current state value stream map that includes both EHS icons and environmental data for each process. In this case, each process box lists the amount of hazardous waste generated by that process per shift in addition to commonly collected data on cycle time (C/T), changeover time (C/O), and machine uptime.

Figure 3: Current State Value Stream Map with Environmental Data



To Consider

- Which environmental metric(s) would you choose to include in value stream maps at your company?
- Does your company or facility have environmental goals and targets that could be identified on value stream maps?
- What processes at your company do you think might have the greatest opportunities for environmental improvement?

3. Analyze Materials Use Versus Need in a "Materials Line" for Value Stream Maps

Key Point

Value stream maps typically examine the time it takes to produce a product and the proportion of that time that is value added, but they do not focus on the resources consumed and wasted in the development of that product. Raw materials are often a large source of a product's costs, so looking explicitly at the material flows in a value stream is another way to leverage greater gains.

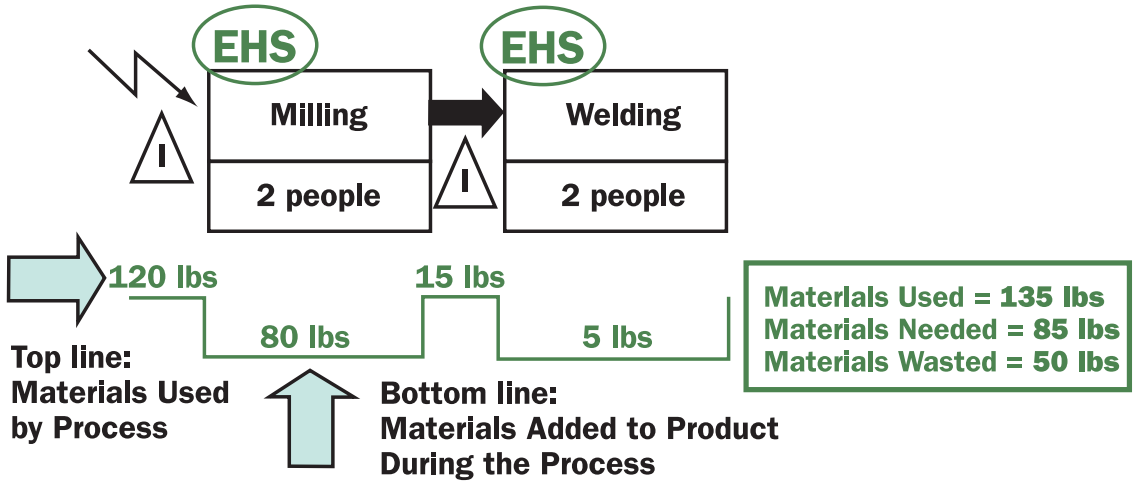
New Tool

One way to do this is to draw a *"materials line"* on the bottom of a value stream map that shows two types of data:

- Amount of raw materials used by each process in the value stream; and
- Amount of materials that end up in the product and add value from a customer's perspective.

The materials line is analogous to the "timeline" on value stream maps, and can be developed for any type of resource (e.g., water, energy, total materials, and/or a critical substance used in the product). Figure 4 shows an example of a materials line. In this example, the milling and welding processes consumed 135 pounds of materials, but only 85 pounds were actually needed and added to the product. Fifty pounds of materials were wasted.

Figure 4: Example "Materials Line" Showing Materials Use Versus Need



Once you collect data for the materials line, you may notice large differences between the amount of material used and the amount needed for the product. This can help you target Lean improvement efforts on the largest sources of waste. Figure 5 shows a complete example of a value stream map with a materials line.

4. Expand the Application of Value Stream Mapping to Natural Resource Flows

In contrast to adding a materials line to a conventional value stream map (as discussed above), you can also use value stream maps to look in more detail at the inputs, outputs, and information flows associated with the use of energy, water, and/or materials. Along with comparing materials use versus the need for each process in the value stream, you can examine environmental waste streams (i.e., non-product outputs such as air emissions, wastewater, hazardous wastes, and trash) and the flows of information to environmental regulatory agencies.

Figure 6 displays a water-use value stream map for a product that contains water (e.g., a medical IV bag). This value stream map includes a materials line summarizing the amount of water that is used and needed by each process in the value stream. There are arrows showing the flow of wastewater from each process to the sewer and another arrow depicting the flow of information about wastewater discharges to regulatory agencies.

This type of detailed examination of material flows can help you find hidden sources of waste in the value stream. All three elements of a materials-flow value stream map—the materials line, environmental waste flows, and regulatory information flows—can also be targets for future Lean efforts.

Figure 5: Current State Value Stream Map with Materials Line

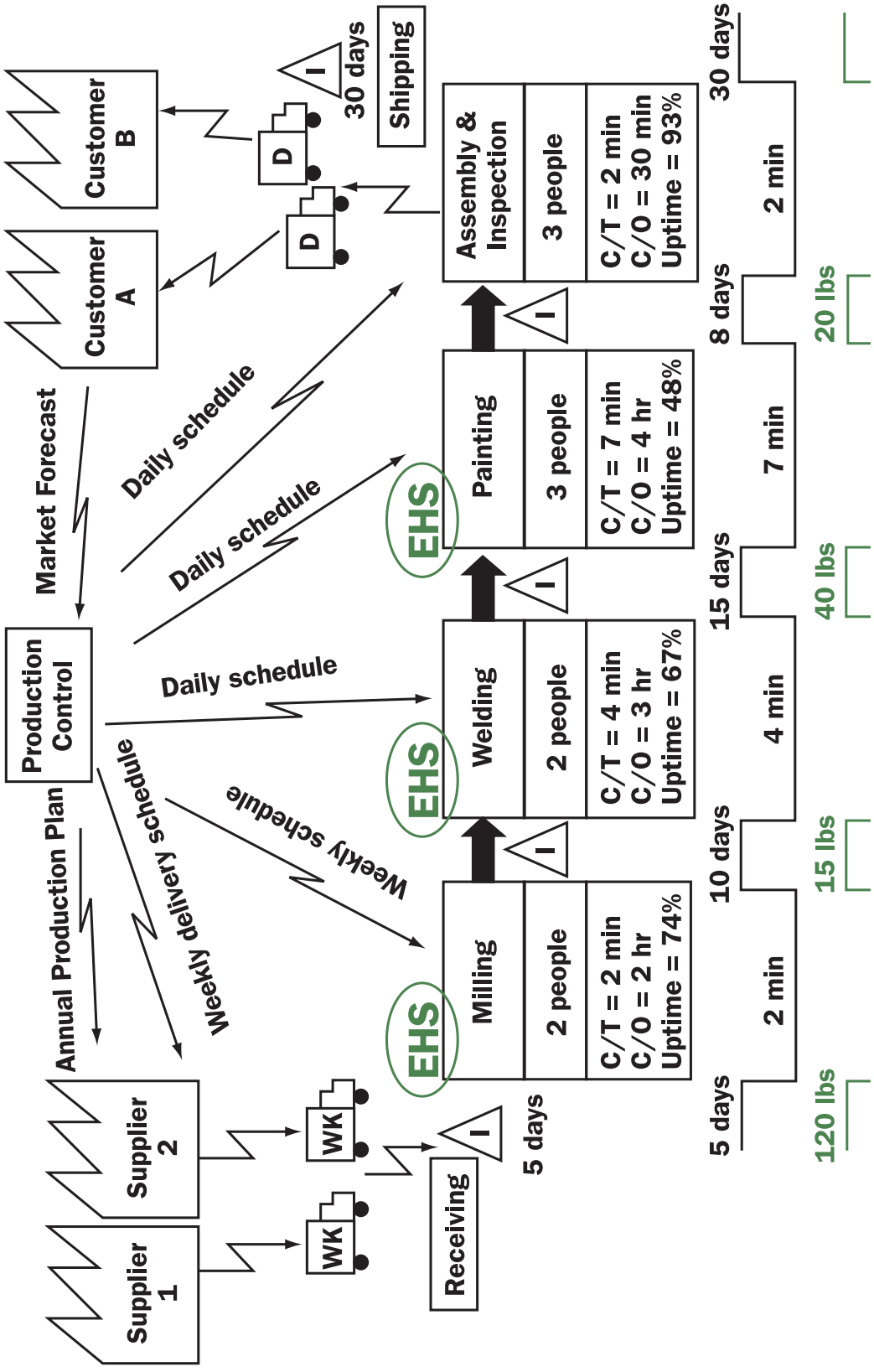
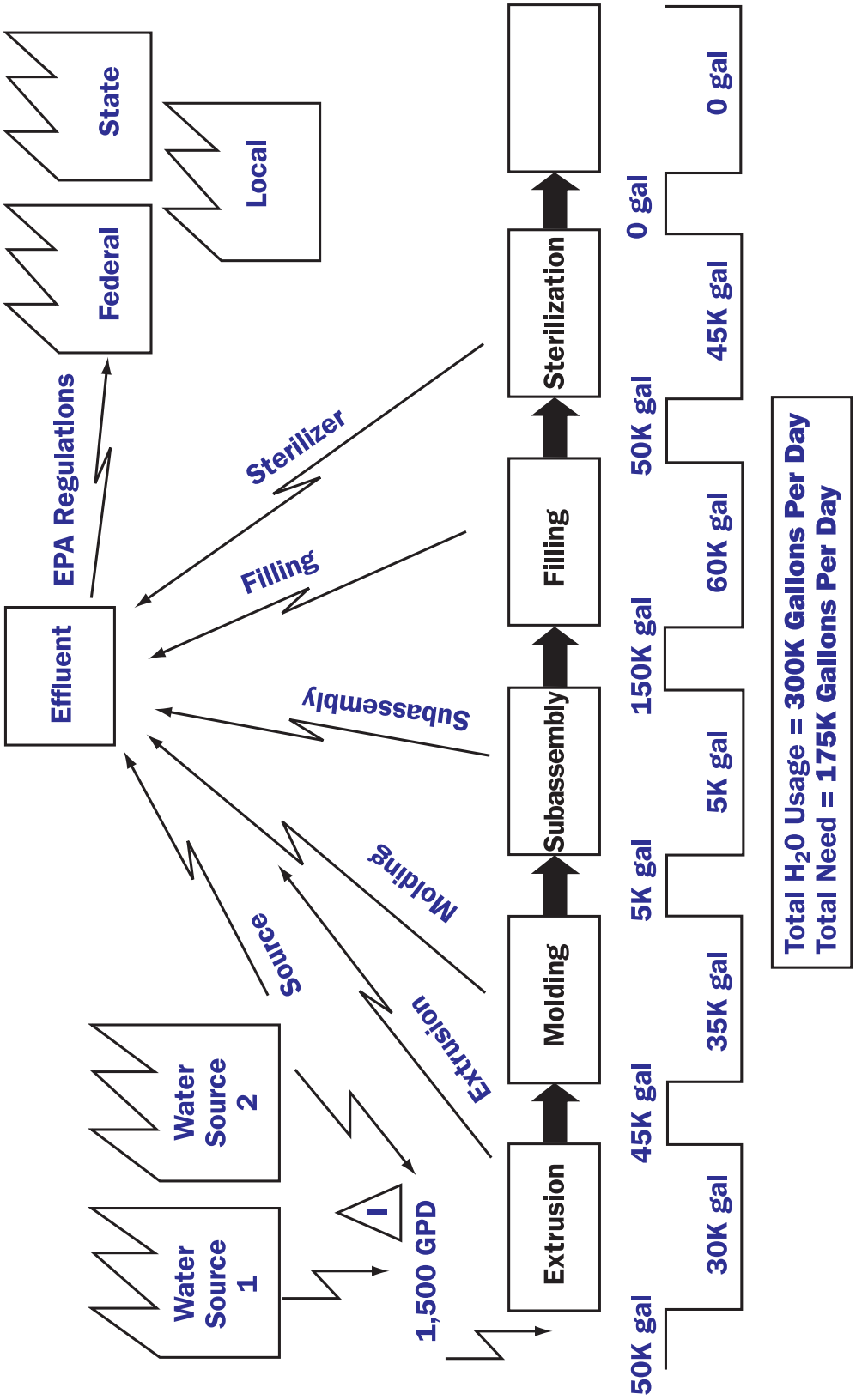


Figure 6: Water Use Value Stream Map (Current State)



5. Find Lean and Environment Opportunities in Future State Value Stream Maps

All the tools and techniques described thus far in this chapter—EHS icons, environmental metrics, addition of a materials line, and materials-flow tracking— can help you identify environmental wastes in the current state of the value stream as well as identify targets for future Lean implementation activities.

Consider the following Questions about the *Future State of a Value Stream* when developing the future state value stream map. These questions, along with input from any EHS staff participating in your team, can help to:

- Envision ways to eliminate environmental wastes in the value stream; and
- Recognize when Lean improvement events could raise EHS compliance issues and, therefore, require involvement of staff with EHS expertise.

Questions About the Future State of a Value Stream

✓ Where are kaizen events (discussed in Chapter 4) needed to address the biggest areas of environmental wastes? These might include:
  - Processes with high energy, water, and/or materials use; and
  - Processes that generate large amounts of solid waste, hazardous waste, and/or pollution

✓ Will any changes be made to the layout of processes marked with an EHS icon or to the chemicals used by those processes? (These changes could have potential implications for regulatory compliance practices.

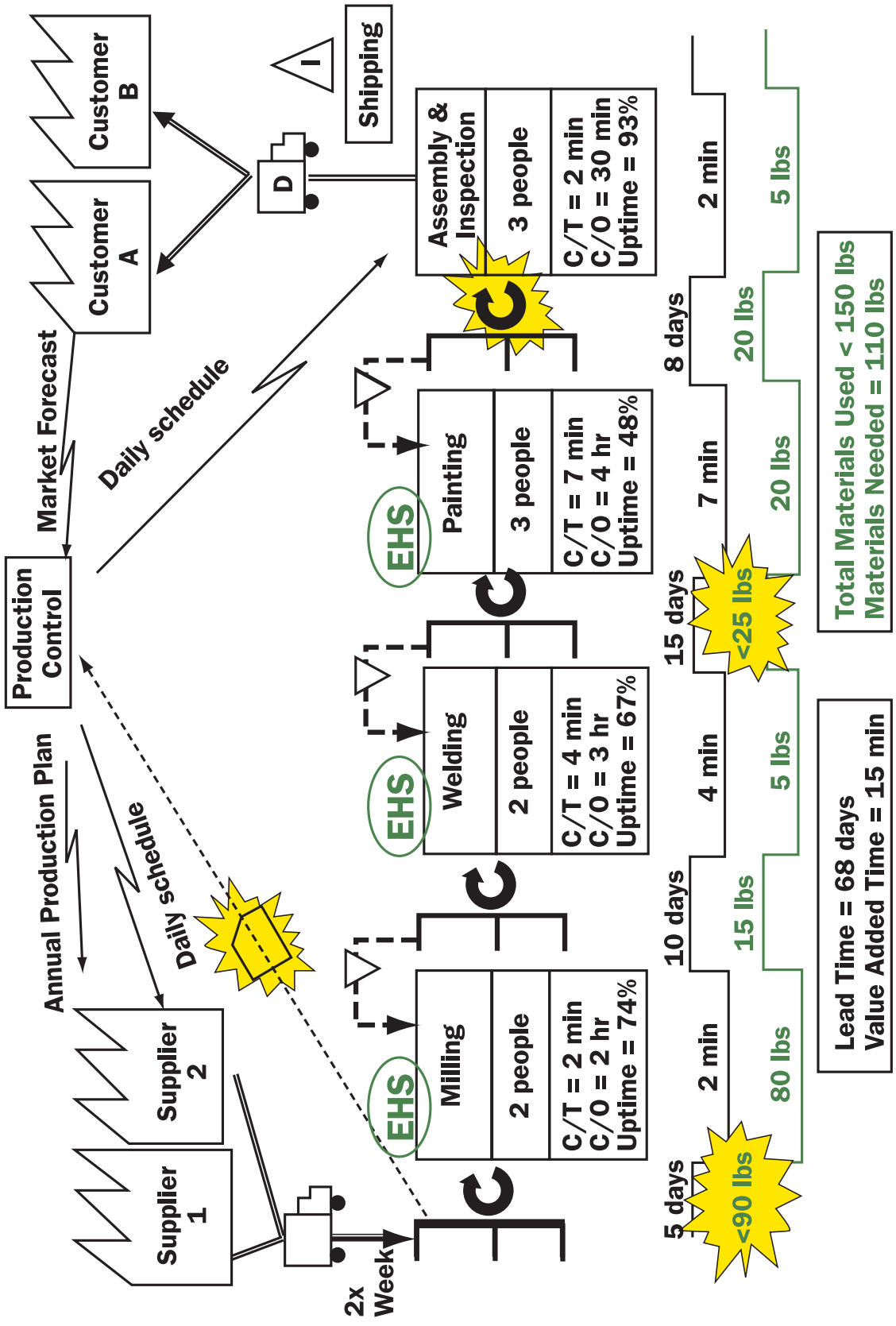
✓ Can one process use the "waste" material from another process instead of using virgin materials?

✓ What would an ideal state for the value stream look like with zero wastes, where products and processes posed no risks to health or the environment, and where there was no need for permits?

✓ What steps can be taken now to get to that ideal state?

Figure 7 depicts a future state value stream map that includes kaizen starbursts for environmental improvement opportunities as well as changes to establish a "pull" system to control inventory levels and improve production flow.

Figure 7: Future State Value Stream Map with EHS Icons and a Materials Line



When developing the kaizen implementation plan associated with the future state value stream map, remember that Lean events on certain processes (including processes with environmental regulatory requirements and others labeled with EHS icons) may require special attention to EHS issues.

Case Study: Baxter International Healthcare Corporation

Baxter Healthcare Corp., a worldwide leader in manufacturing global medical products, adopted a number of Lean techniques to reduce its environmental footprint. Baxter integrated environmental metrics with traditional Lean manufacturing tools, helping the company double in size and revenue while keeping total waste generation close to 1996 levels. Several company plants completed a value stream map (VSM) to find ways to reduce water and energy consumption. One plant developed a VSM and implementation plans by walking through the production process and highlighting water usage and major processing steps. In the VSM, 96 opportunities were prioritized with many graphically represented by starbursts; these opportunities were also included in three future state VSMs. Through the VSM event, Baxter developed an action plan that should save $17,000 over three months and 170,000 gallons of water per day.

It is critical to involve staff with EHS expertise early in planning for Lean events on processes with EHS opportunities. EHS staff can:

- Anticipate changes needed to environmental compliance practices from Lean activities and help implement those changes as quickly as possible;
- Bring a different perspective to Lean activities and additional ideas for waste-reduction opportunities; and
- Ensure that Lean activities improve or cause no harm to worker health, safety or the environment.

In the next chapter you will learn more about how to integrate environmental considerations into the implementation of kaizen events at your company.

Summary

Value stream mapping is a Lean process-mapping method for understanding the sequence of activities and information flows used to produce a product or deliver a service. Conventional value stream mapping can overlook three types of environmental considerations:

- Raw materials used in products and processes;
- Pollution and other environmental wastes in the value stream; and
- Flows of information to environmental regulatory agencies.

There are at least five ways to explicitly address pollution and natural resource wastes using value stream mapping:

1. Use icons to identify processes with EHS opportunities in value stream maps, and involve EHS staff in planning Lean events on those processes.
2. Record environmental performance data for processes in value stream maps, and consider these data in developing a vision for the future state.
3. Analyze materials used by each process versus materials actually needed for the product, and summarize this information in a "materials line" below the timeline on value stream maps.
4. Expand the application of value stream mapping to natural resource flows such as energy and water use, by including additional information on materials use, waste streams, and regulatory information flows in the maps.
5. Consider Lean and environment questions, as well as environmental data included in the current state map, when developing the future state map.

EHS professionals can help to:

- Collect environmental performance data for processes in the value stream;
- Identify processes with environmental opportunities in value stream maps; and
- Make sure that changes to those processes are managed safely and effectively through Lean implementation.

Your Thoughts

Now that you've finished this chapter, reflect on what you read by answering these questions:

- Do you need any more information to fully understand how to integrate environmental, health and safety considerations into value stream mapping? Would any other tools be helpful?
- What other ideas do you have to improve the environmental performance of your company with value stream mapping?

Notes:

CHAPTER 4
Kaizen Events

Chapter Contents

Introduction to Kaizen Events

This chapter looks at one of the main vehicles for change in Lean—kaizen or rapid process improvement events—and discusses how to find environmental improvement opportunities, mitigate regulatory constraints, and implement new waste-reduction tools through kaizen events on processes in the value stream.

Definition of Kaizen

Kaizen means continual improvement in Japanese. Kaizen events—also known as rapid process improvement events—are a team activity designed to eliminate waste and make rapid changes in the workplace. They are a primary means of implementing other Lean methods, ranging from 6S (5S+Safety) to cellular manufacturing. See Appendix A for more information about kaizen events.

What This Chapter Will Help You Do

The rapid and fundamental process changes that occur during kaizen events create powerful windows of opportunity to reduce material wastes and pollution, but they also can result in regulatory compliance violations and/or cause health and safety hazards for workers if they are not properly managed. This is especially the case for the *10 Common Manufacturing Processes with Environmental Opportunities* listed on page 24.

This chapter presents strategies and tools to help accomplish two objectives:

1. Develop a change management system for kaizen events to prevent regulatory compliance issues and maximize waste-reduction benefits; and

2. Find opportunities to enhance Lean results and environmental outcomes by asking key questions and deploying new process-improvement tools.

How to Establish a Lean and Environment Change Management System

Overview of Process Steps

In addition to involving EHS staff in value stream mapping teams (see Chapter 3), there are four steps your company could take to make sure that process changes from kaizen events do not cause unwanted EHS impacts.

1. Train Lean team leaders to recognize EHS impacts.

2. Identify an EHS contact for kaizen event teams.

3. Use an EHS Checklist for Lean events to identify EHS needs.

4. Proactively involve EHS staff in Lean events.

Step 1: Train Lean Team Leaders to Recognize EHS Impacts

While a key strategy for effective Lean and environment integration is to involve EHS staff in planning for and conducting Lean events on processes with environmental opportunities, it is useful for all staff to recognize what process changes can trigger EHS impacts. *Simple training can go a long way to help kaizen event team leaders and team members identify issues and operational changes that may require additional EHS expertise*. As described in more detail in Chapter 2, consider adding slides to Lean training presentations about how to identify environmental wastes and issues during Lean activities.

Use the list of *Common Operational Changes That Trigger EHS Involvement* below as a guide for when to seek additional EHS expertise for Lean events.

Common Operational Changes That Trigger EHS Involvement

- ✓ Changes to the type, volume, or introduction/issuance procedure for chemicals/materials used by employees. *Affects chemical exposure, regulatory compliance, and reporting needs.*
- ✓ Changes to the type or volume of waste generated by a process, including all media such as air emissions, water discharges, and liquid and solid waste. *Affects compliance with regulatory and permitted limits, as well as pollution control and management capacity.*
- ✓ Changes to the physical layout of the processes (e.g., moving work or storage areas), to equipment and technologies used, or to the facility (e.g., moving, replacing, or installing vent hoods, stacks, floor drains or process tanks). *Affects compliance with regulations and permits, as well as work practice requirements.*

If not properly conducted, these types of operational changes could harm the health and safety of workers, or cause violations of EHS regulations. For example, moving hazardous waste collection areas from central locations to work cells could affect compliance with the Resource Conservation and Recovery Act. Similarly, replacing existing, permitted air pollution control equipment with right-sized equipment would require permit modifications under the Clean Air Act.

Step 2: Identify an EHS Contact for Kaizen Event Teams

Lean managers and kaizen team leaders need to know who to contact with EHS questions and needs. Since EHS specialists cannot participate in all Lean events, it can be helpful to assign a general EHS contact to address unexpected issues and concerns that arise during kaizen events.

Your company may wish to have a single EHS contact for all events, or assign EHS staff to specific production areas. Here are a few things to keep in mind when identifying an EHS contact.

- **Keep it simple.** Have a single point of contact for the event.
- **Provide EHS contact information.** Give kaizen event team leaders information on how to reach the EHS contact.
- **Assign EHS contacts who can be highly responsive.** Even a one-day delay in response to a question or issue can disrupt progress in an event.

Step 3: Use an EHS Checklist for Lean Events to Identify EHS Needs

An EHS checklist for Lean events is a simple tool you can use to identify operational changes planned during a kaizen event that may cause an EHS impact. Checklists are particularly useful when there is no team member with EHS expertise involved in an event. They also reinforce training information.

See Appendix C for a sample *Lean Event EHS Checklist*. If your company has other checklists or forms used during Lean events, you could add EHS-related information to them. You may also want to include questions that prompt team members to look specifically for environmental improvement opportunities.

Step 4: Proactively Involve EHS Staff in Kaizen Events

In Chapter 3, you learned how to identify processes with environmental opportunities on value stream maps and that you should involve EHS staff in Lean events on those processes. The Lean Event EHS Checklist can also serve as a trigger for EHS involvement. *Kaizen event teams should consult the EHS contact immediately during an event if any EHS involvement flags are triggered when completing the checklist.* Failure to involve EHS staff can result in risks due to unsafe work conditions or non-compliance with regulations.

Case Study: Goodrich Corporation

Goodrich, a supplier of products and services to the aerospace industry, began implementing Lean techniques in 1995, adapting tools from the Toyota Production System. Kaizen events serve as the driving force behind a waste elimination-focused culture change with the company conducting over 350 events each. Goodrich has used kaizen events to assess hazardous environmental waste streams, identify and implement pollution prevention and process improvement techniques, and to target environmental, health, and safety (EHS) issues. EHS objectives must be identified for all kaizen events, and efforts must also be made to involve EHS personnel if an event is likely to have important environmental dimensions, risks, or opportunities. Several Goodrich sites have also converted to cellular manufacturing while other facilities have shifted to Lean point of use chemical management systems to eliminate wasted worker movement, which also reduced chemical use.

While involvement of EHS staff can sometimes result in the identification of constraints to making certain operational changes, their participation can also expand the solution set. In some cases, EHS staff may even be able to work with regulatory agencies to tailor permit requirements and compliance strategies to accommodate your plant's Lean operating environment (see Air Permitting Strategies textbox below).

Air Permitting Strategies to Reduce Constraints to Making Operational Changes

The U.S. Environmental Protection Agency and various States have pioneered innovative approaches to air permitting that can streamline a plant's ability to make many types of operational changes. Many of these flexible air permitting techniques are being piloted by companies implementing Lean. To learn more about innovations in air permitting, use the form found at http://www.epa.gov/lean/auxfiles/contact.htm to get in touch with an EPA Lean and environment specialist.

To Consider

- What EHS issues and questions have arisen during kaizen events in your organization? Which ones have recurred?
- Identify at least three ways to improve coordination between Lean and EHS personnel regarding kaizen events.

How to Identify and Find Solutions for Lean and Environment Opportunities in Kaizen Events

While the previous chapter described how to identify processes with EHS opportunities in value stream maps, this chapter presents several tools and resources for finding Lean and environment opportunities within specific processes targeted for kaizen implementation. These resources include:

- Questions to Identify Lean-Environment Opportunities;
- Hierarchical Process Mapping to Drill Down from Value Stream Maps; and
- Process-Specific Pollution Prevention Resources.

These kaizen implementation resources can help Lean teams discover ways to improve environmental and operational performance. They are particularly useful when planning for kaizen events and during initial brainstorming activities.

1. Questions to Identify Lean-Environment Opportunities

Asking the right questions when preparing for and conducting a kaizen event can uncover hidden waste reduction opportunities, such as chemicals that could harm human health and the environment, water and energy utilities, and compliance support infrastructure and costs that may be buried in facility overhead.

The Key Questions for Identifying Lean-Environment Opportunities listed below can assist your kaizen team to explicitly identify and consider opportunities to boost environmental performance while also enhancing operational performance.

Key Questions for Identifying Lean-Environment Opportunities

Water Use

✓ How much water is used in the process and how is it used?
✓ How can you reuse water and/or reduce overall water use?
✓ Can you reduce contaminants in wastewater and discharges?

Energy Use

✓ How much energy is used in the process and how is it used?
✓ How can you reduce overall energy use?
✓ Is equipment running or are lights on when not being used?
✓ Are you using efficient light bulbs?
✓ Can you save energy by consolidating operations and/or storage space?
✓ Can you shift to a cleaner source of energy?

Chemicals and Materials Use

✓ What types and quantities of chemicals/materials are used in the process?
✓ How can you reduce the overall amount of chemicals and materials used?
✓ Can you switch to less harmful chemicals?
✓ Can you eliminate any non-value added use of chemicals or materials from the product or process (excess packaging, unneeded painting, etc.)?

Solid Waste

✓ What types and quantities of solid waste are generated by the process?
✓ How can you reduce the overall amount of solid waste generated?
✓ How can you reuse or recycle solid wastes?
✓ Is there a local composting facility that the waste can be taken to?

Hazardous Waste

✓ What types and quantities of hazardous waste are generated by the process?
✓ How can you reduce the amount or toxicity of hazardous waste generated?
✓ Can you better isolate and separate hazardous wastes from other wastes?

Air Emissions

✓ What types and amounts of air emissions are generated by the process?
✓ How can you reduce the overall amount or toxicity of air emissions?
✓ How far did vehicles travel to deliver parts and supplies?

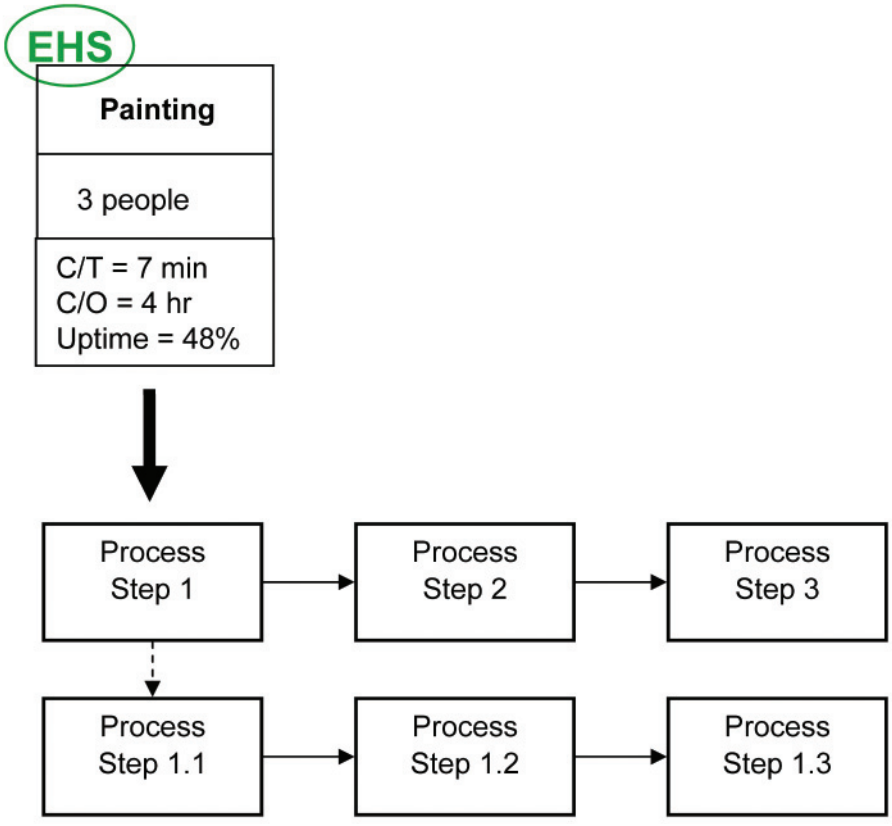
2. Hierarchical Process Mapping to Drill Down from Value Stream Maps

The value stream mapping tools described in Chapter 3 can help identify which processes generate large amounts of environmental wastes. Sometimes, however, it is useful to drill down further to identify the specific sources of waste within a single process. This detailed information can be particularly useful when preparing for or conducting a kaizen improvement event. Hierarchical process mapping is one tool to conduct this more detailed analysis and thereby uncover new waste-reduction opportunities.

Key Term

Hierarchical process mapping is a tool that creates a workflow diagram to bring forth a clearer understanding of steps within a specific process.[1] For example, a plating process might involve several individual operations. A *hierarchical process map* presents process steps in tiers—it presents a high-level map of up to six process steps, and then maps the specific steps that lie within each high-level step, and so on with tiers of increasing detail. Figure 8 shows how hierarchical process mapping can be used to drill down within a process in a value stream.

Figure 8: Drilling Down with Hierarchical Process Mapping



[1] This section draws on pioneering work on process mapping by Robert B. Pojasek (www. pojasek-associates.com). S ee Robert B. Pojasek, "Mapping Information Flow Through the Production Process," *Environmental Quality Management*, 13 (3), 2004.

How-to Steps

There are six main steps associated with process mapping.

1. Select the target process and determine map perspective and boundaries.
2. Collect information.
3. Draw the top-level map, and then draw more levels as needed.
4. Verify the map of process steps with employees and revise as needed.
5. Develop process step description and accounting sheets for process steps at the lowest level of the map.
6. Feed hierarchical process mapping information into improvement events.

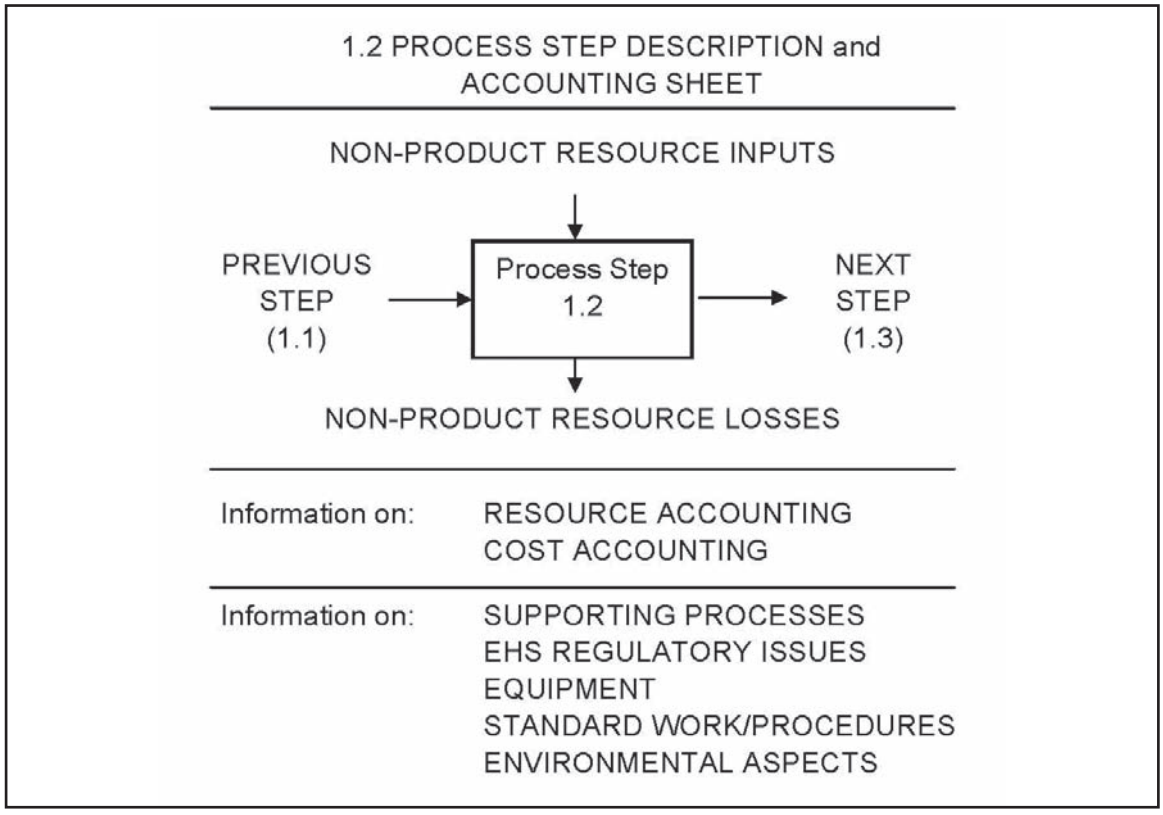
At the lowest level of the hierarchical process maps, it can be useful to collect information on:

- Resource inputs and non-product outputs such as pollution and scrap for each process step;
- Resource and cost accounting data; and
- Regulatory issues and requirements.

New Tool

Process mapping captures this information in *Process Step Description and Accounting Sheets*, as in the template and example below (see Figures 9 and 10).

Figure 9: Process Step Description and Accounting Sheet (Template)

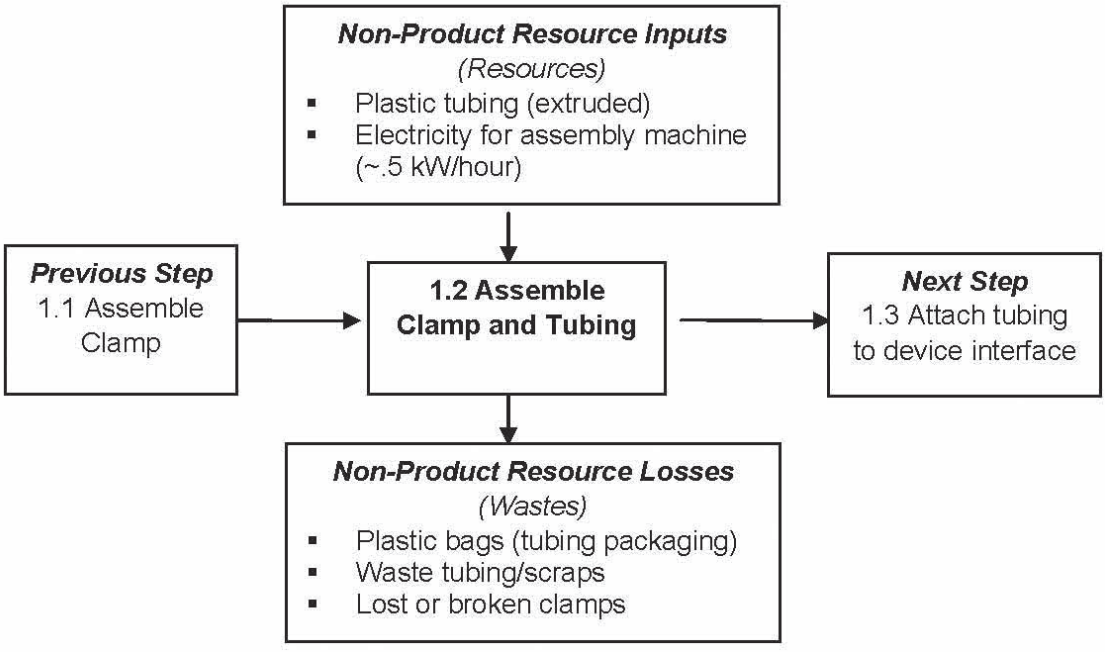


Your Lean implementation team can use process mapping sheets based on this template to collect data about one or more processes in a value stream, find the root causes of environmental wastes, and understand the full costs and requirements associated with these wastes. With that information, you can target kaizen events on the specific process steps that are the largest sources of waste.

Figure 10: Process Step Description and Accounting Sheet (Sample)

Assemble Clamp and Tubing
(Assembly Process)

Description of Work Step:
The side clamp is fed into the machine. The plastic tubing is fed into the machine and passed through the clamp. The tubing is cut to size. The machine verifies the length of the tubing and the presence of the side clamps.



Supporting Processes:
- Recycling – plastic tubing scrap, plastic bags (~10 lbs./shift)
- Storage and handling of parts
- Maintenance and lubrication of assembly machine
- Cleaning of part feeding station
- Particulate matter (PM) sensors
- Compressed air
- Exhaust

No environmental regulatory requirements are associated with this process step.

To Consider

- What three processes at your company could benefit from hierarchical process mapping?
- Who would you need to talk to about doing hierarchical process mapping on those processes?

3. Process-Specific Resources for Kaizen Implementation

Over the past 20 years, manufacturing assistance programs and environmental agencies have assembled vast libraries of information on process-specific technologies, tools, techniques, and work practices that can improve your operational performance and cause less harm to worker health and the environment. These resources are particularly relevant to the 10 manufacturing processes with environmental opportunities described in Chapter 3 (see page 24).

See the textbox below and Appendix D for more information about these pollution prevention resources. Future versions of the *Lean and Environment Toolkit* may include information and tools for increasing the Lean and environmental improvement results when applying Lean methods to specific types of processes, such as chemical management, painting, and electroplating.

Sources of Information on Process Improvement and Pollution Prevention

There are numerous resources available on specific process improvement and pollution prevention techniques and technologies. Two examples are given below. For a list of additional resources please see Appendix D.

- *Pollution Prevention* (P2) from the U.S. Environmental Protection Agency, http://www.epa.gov/p2/
  This comprehensive site includes information organized for different P2 audiences, programs, concepts, and product stages. It contains numerous links to databases, tools, publications, funding opportunities, and regional programs.
- *Pollution Prevention Resource Exchange (P2Rx)*, http://www.p2rx.org
  P2Rx is a national network of regional information centers and resources on pollution prevention including breaking news, research and publications, and regional and national networking opportunities.

Summary

Kaizen events are team-based activities designed to eliminate waste and make rapid changes in the workplace through the targeted use of Lean methods. If not properly managed, the operational changes made through kaizen events could harm the health and safety of workers or result in violations of regulatory compliance requirements.

To prevent these problems, it is important to establish an effective EHS change management system for Lean events. This can involve four steps:

1. Train kaizen event team leaders to identify operational changes that may trigger EHS involvement. These include changes that affect chemical exposure, compliance with regulations and permits, pollution control management capacity, and work practice requirements.
2. Identify a responsive EHS contact that Lean managers and kaizen team leaders can contact with EHS questions and needs.
3. Fill out a Lean Event EHS Checklist for each Lean event. This simple tool identifies operational changes planned during a kaizen event that may warrant the involvement of EHS expertise.
4. Involve EHS representatives in Lean events early on to anticipate and address potential EHS compliance issues and avoid risks to workers.

Tools to support the planning and implementation of kaizen events include:

- Questions to identify Lean-environment opportunities in kaizen events;
- Hierarchical process mapping, which can drill down from value stream maps to uncover specific sources of waste within a single process; and
- Process-specific pollution prevention resources to improve business results and cause less harm to human health and the environment.

Your Thoughts

Now that you've finished this chapter, reflect on what you read by answering these questions:

- What did you learn in this chapter that was particularly useful?
- Do you need any more information to fully understand how to integrate environmental, health and safety considerations into kaizen events? Would any other tools be helpful?
- What other ideas do you have to improve the environmental performance of your company with kaizen events?

Notes:

CHAPTER 5
6S (5S+Safety)

Chapter Contents

Introduction to 6S

This chapter focuses on making improvements to work areas using 6S, a variation of the 5S method. 6S can be a powerful way to reduce risks, improve waste management, and ensure that your facility is a safe and healthy place to work.

Definition of 6S

6S is a method used to create and maintain a clean, orderly, and safe work environment. 6S is based upon the five pillars (5S) of the visual workplace in the Toyota Production System, plus a separate pillar for safety. 6S is often the first method companies implement in their Lean journey, since it serves as the foundation of future continual improvement efforts. More detailed information on 6S can be found in Appendix A.

The Six Pillars of 6S

6S consists of six pillars:

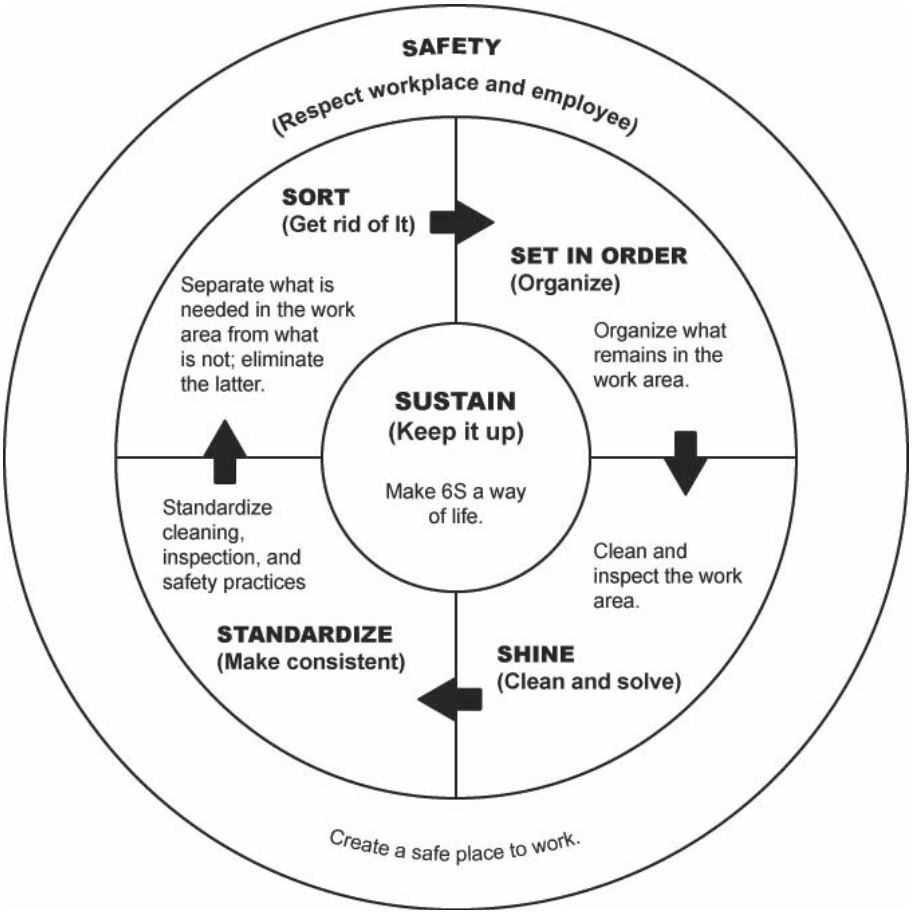
1. **Sort (Get rid of it):** Separate what is needed in the work area from what is not; eliminate the latter.
2. **Set in order (Organize):** Organize what remains in the work area.
3. **Shine (Clean and solve):** Clean and inspect the work area.
4. **Safety (Respect workplace and employee):** Create a safe place to work.
5. **Standardize (Make consistent):** Standardize cleaning, inspection, and safety practices.
6. **Sustain (Keep it up):** Make 6S a way of life.

The six pillars work together to support improvement efforts at your company. They help increase productivity, reduce defects, make accidents less likely, and reduce costs. *6S also fosters a culture of continual improvement and employee engagement that is essential for successful implementation of Lean.* 6S often makes it easier to implement other Lean methods such as cellular manufacturing, one-piece flow, and just-in-time production.

Case Study: Robins Air Force Base

Robins Air Force Base houses the Warner Robins Air Logistics Center, a major depot for repairing aircraft and producing spare parts for the U.S. Air Force. The Base implemented point of use cabinet systems through kaizen events, 6S, and visual controls to reduce the time and distance that workers travel to retrieve hazardous materials and the amount of waste generated. Value stream mapping and 6S were used to set up a system for collecting and transporting hazardous wastes, which eliminated process steps, saved time handling wastes, and reduced how often waste drums were handled. Robins AFB reorganized its hazardous waste management facility using 6S and visual controls to enhance the monitoring of waste management processes and decrease the chance of accidents and spills. The C-130 Aircraft Paint Shop used 6S to improve its paint system, which increased productivity, improved worker safety, and decreased volatile organic compound emissions, chemical use, and storage space.

Figure 11: The Six Pillars of 6S



What This Chapter Will Help You Do

Environmental wastes can be a symptom of a suboptimal system. 6S can help your company reduce waste and improve environmental performance leading to increased system productivity. *You can also use 6S to minimize risks to the health of workers and the environment.* Full implementation of 6S requires looking not only at the quantity, usefulness, and frequency with which an item is used in a work area, but also the risk or toxicity of the item. It also means paying close attention to what ends up in waste streams and how to manage those wastes.

Expanding the scope of 6S to include EHS concerns can help your company to:

- Make defects less likely, so less energy and materials are wasted;
- Reduce the chance that paint, solvent, or other chemicals expire or become off-specification before they can be used and then require disposal;
- Save floor space, which makes it possible to save energy costs by consolidating operations and closing unneeded storage areas;
- Avoid productivity losses from injuries and occupational health hazards by providing clean and accident-free work areas; and
- Prevent environmental and occupational health and safety compliance issues by preventing or quickly correcting any spill or leaks.

To Consider

- Name at least three ways your company could use 6S to improve its environmental performance and reduce wastes.
- What metrics could you us to track environmental, health, and safety improvements from 6S activities?
- What ideas do you have for improving your work area?

EHS issues are relevant to all six pillars of 6S. As a starting point, this toolkit describes how to:

- **Distinguish between hazardous and nonhazardous items in your work area during Sort—an initial step in 6S.** Use yellow tags or other visual cues in red-tagging to identify EHS issues, harmful materials, and environmental wastes.
- **Incorporate questions about EHS issues into the inspection and evaluation activities that occur in the Shine and Sustain pillars.** Inspect work areas in plant-wide and area-specific 6S inspections and audits to make sure that EHS concerns are managed properly.

Some additional ideas on how to incorporate EHS concerns into the 6S process are given in the box below.

6S Implementation Tips

- ✓ If you need to paint equipment, use low-toxic paint in white or a light color. This can help save lighting and energy costs.
- ✓ Use different colored containers for hazardous wastes, recycling, and other non-hazardous wastes.
- ✓ Mark aerosol cans with colored dots to indicate where to dispose of them.
- ✓ Try using environmentally friendly cleaning supplies.
- ✓ Separate hazardous from non-hazardous materials and wastes in red-tag holding areas.

How to Identify EHS Issues during "Sort"

Overview of Yellow-Tagging

The objective of Sort is to identify items that are not needed in a work area and to get rid of them. This is done through a process called red-tagging. During a red-tagging project, you can examine your work area to identify any environmental, health, and safety issues at the same time, using yellow tags or other visual cues.

A yellow-tag strategy is a simple method of identifying environmental wastes and items that may be harmful to human health or the environment in the work area, evaluating the need for these items and potential alternatives, and addressing them appropriately. A yellow-tag strategy is designed to supplement a red-tag strategy. Yellow tags highlight EHS hazards or improvement opportunities.

The basic steps in yellow-tagging are the same as in red-tagging, so you can implement them together or separately. The process can be divided into four steps.

1. Identify yellow-tag targets and criteria.
2. Make and attach yellow tags.
3. Evaluate and take care of yellow-tagged items.
4. Document the results.

Step 1: Identify Yellow-Tag Targets and Criteria

At the start of a yellow-tagging project, your team should identify two types of targets: (a) the physical areas where tagging will take place; and (b) the specific types of items you will evaluate. *Involve*

EHS personnel in your yellow-tagging team to help you find additional wastes and opportunities for improvement.

Potential items to consider in yellow-tagging include:

- EHS hazards in the workplace;
- Chemicals and other hazardous materials; and
- Environmental wastes.

After choosing targets, your team should agree on criteria for evaluating yellow-tagged items. You can continue to use red-tagging and your company's red-tag criteria to determine whether an item is needed in the work area based on its usefulness for the work at hand, the frequency with which it is used, and the quantity that is needed. For yellow tags, you may want to use criteria related to the risk of an item, the availability of alternative materials or equipment, or to an opportunity for improved environmental performance.

Yellow tags can serve as warning tags that alert workers about existing or potential hazards in the work area or that identify potential areas to target for improvement in the future. For example, a yellow tag on a chemical could cause you to ask whether a less toxic material could be used for the same purpose. Similarly, a yellow tag on an item in a red-tag holding area could indicate that the item needs to be treated differently for disposal or reuse because of its risk.

Step 2: Make and Attach Yellow Tags

Yellow tags could be as simple as yellow sticky notes stating the reason for the yellow tag, or they could also contain standard data that will allow your company to evaluate performance improvements from 6S and that will support your company's overall materials tracking system. An example *yellow tag* is below.

YELLOW TAG

Category (circle one)	1. Health or safety concern 2. Environmental concern		
Item Name and Number			
Description of Issue or Question			
Division Responsible:		Date:	

It is best to attach yellow tags to items during a short, focused event, to get a snapshot of the current state of the work area. Unless there is an immediate danger to people's safety, do not spend time at this stage correcting issues or evaluating what to do with items. Instead, use the yellow tags to highlight potential EHS issues or opportunities in the target work area.

Step 3: Evaluate and Take Care of Yellow-Tagged Items

The next step involves applying the criteria from Step 1 to determine what to do with yellow-tagged items.

- If you found a safety, health, or environmental issue while yellow-tagging, such as a compliance violation or excess environmental waste, ask "why" five times to identify the root cause of it (see example below) and then ask "how" to address it.
- If an item is both unnecessary (red-tagged) and hazardous (yellow-tagged), be sure to follow appropriate procedures for disposal of hazardous wastes.
- If there are hazardous items remaining in a work area after doing Sort (items with a yellow tag but not a red tag), find out whether you can avoid the need to use those materials, or whether there is a less toxic alternative.

Asking Why Five Times[2]

1. *Why are we using so much water?*
   The parts need to be cleaned before painting.
2. *Why do the parts need to be cleaned?*
   The parts fail quality checks if they aren't cleaned before being painted.
3. *Why do painted parts fail quality checks?*
   The paint doesn't adhere when part surfaces are not prepared properly.
4. *Why do the surfaces of the part need to be prepared?*
   The surfaces get contaminated with oils in the previous process.
5. *Why are oils used in the previous process?*
   The oils are used to prevent corrosion during storage.

Step 4: Document Results

The final step in a yellow-tag strategy is to document necessary information from the yellow-tagging process in a log book or other tracking system your company uses. This should be done at the same time as you record data from red tags, ideally as part of the same system. This will allow you to track the improvements and savings that have resulted from your yellow-tagging efforts.

[2] Based on an example from Robert B. Pojasek, "Asking 'Why?' Five Times," Environmental Quality Management (Autumn 2006): 83.

As with any Lean project, it is important to share your results with others, celebrate your success, and identify any follow-up items. Posting the results of yellow-tagging projects on activity boards can show others at your company what you have been able to achieve and can generate ideas for further improvement.

To Consider

- Name three types of items and three locations that you could target for yellow-tagging at your company.
- What criteria would you use for identifying issues?
- Name three improvements or savings that would result from a yellow-tagging event at your company.

How to Incorporate EHS into 6S Inspections

Eliminating Environmental Waste and Risk through 6S Inspections

Most companies who implement 6S seek to sustain the improvements made during initial 6S events. Shine activities often include daily cleaning and inspection by workers in their work area. Sustain activities often include weekly or other periodic audits to assess progress with 6S implementation.

Remember that *what gets measured gets managed. By explicitly incorporating EHS items into 6S inspections and audits, you can eliminate more waste and risk from each work area.* 6S inspections and audits can also reinforce workers' awareness of important tasks and issues that affect worker health and safety and environmental performance. For companies implementing an environmental management system (such as an ISO 14001-type EMS), 6S inspections and audits create valuable opportunities to regularly ensure that EHS procedures are followed on the shop floor.

Plant-Wide 6S Inspection Checklists and Audit Questions

Inspection checklists and audit questions are powerful tools to sustain 6S improvements and to prompt the identification of new improvement opportunities.

The list of *6S Inspection and Audit Questions* on page 58 contains questions used by some companies to ensure that environmental wastes and risk are routinely identified, properly managed, and eliminated where possible.

These questions can be adapted to work in a variety of 6S implementation assessment tools, particularly where a common system is used to assess 6S implementation across many work areas. Your company may use a simplified rating system to assess 6S implementation progress, such as a 0–5 rating for each 6S pillar. In this case, these questions can be used to train 6S inspectors and audi-

tors, or to provide background information for a broader rating category or question that focuses on overall efforts to address EHS issues and opportunities in a work area.

Some organizations have developed detailed audit checklists that include, or focus exclusively on, environmental and safety issues. Appendix E includes a sample *6S Audit Checklist* that was developed by a company to focus on safety issues.

Shine Checklists for Specific Work Areas

When developing Shine cleaning and inspection checklists for a work area, it will often be useful to develop additional questions that are tailored to address specific materials, equipment, and/or work practices in that work area. EHS personnel can help to develop specific checklist items and questions that can integrate EHS management procedures and waste identification opportunities into Shine inspections for pollution control equipment, hazardous chemicals, and other aspects of a work area that could pose health or safety hazards to workers.

To Consider

- How well do 6S inspections and audits assess EHS activities and performance in your company?
- What approach might be most appropriate for incorporating EHS considerations into 6S assessment tools in your company?

6S Inspection and Audit Questions for Eliminating Environmental Waste and Risk

Sort (Get rid of it)

- ✓ Are potentially risky items and environmental wastes yellow-tagged?
- ✓ Are all red-tagged and yellow-tagged items being disposed of properly, including those that must be managed as hazardous wastes?

Set in Order (Organize)

- ✓ Are material containers clean, stored off the floor, closed, properly stacked, and stored/staged in the proper areas?
- ✓ Are all containers with chemicals or wastes covered or sealed when not in use?
- ✓ Are all containers with materials, chemicals, and/or wastes properly labeled?
- ✓ Are initial accumulation points for hazardous waste clean and organized, and do they have effective visual controls?

Shine (Clean and solve)

- ✓ Are any leaks evident from equipment, piping, tanks, exhaust lines, or other areas in the workplace?
- ✓ Is air quality in the work area good and free of dust, odors, and fumes? Is air flow in the area good? Are ventilation systems clean and unobstructed? Are HEPA filters free of debris, mold, and dirt?
- ✓ Are all drains in good condition, free flowing, and unobstructed? Are all drains properly labeled to ensure that only acceptable substances are disposed down them (e.g., prevent chemicals and wastes from going down storm water drains?
- ✓ Are exterior locations near storm water drains and storm water retention areas free from garbage and debris that can cause obstruction?
- ✓ Are garbage and recyclables collected and sorted correctly? Are recycling containers and bins free from extraneous materials?

Safety (Respect workplace and employee)

- ✓ Are standard work procedures documented and available for the area?
- ✓ Are environment, health, and safety management activities and procedures relevant to the work area integrated into standard work?

Sustain (Keep it up)

- ✓ Are standard work procedures being followed?
- ✓ Are workers in the area aware of chemical hazards associated with standard work tasks?

Summary

6S is modeled after the 5S system designed to reduce waste and optimize productivity through maintaining a clean, orderly workplace and using visual cues to achieve more consistent operational results. 6S uses the 5S pillars with an additional pillar for safety. The six pillars of 6S are:

- Sort (Get rid of it);
- Set in order (Organize);
- Shine (Clean and solve);
- Safety (Respect workplace and employee);
- Standardize (Make consistent); and
- Sustain (Keep it up).

The pillars work together to increase productivity, reduce defects, make accidents less likely, save time, and reduce costs. When expanded to include EHS issues, they can also help reduce hazards and improve environmental performance.

The following four steps provide an example of how EHS issues can be identified and addressed through 6S using yellow tags along with red tags in the Sort process. The objective of this strategy is to identify environmental wastes in the work area with a yellow tag, evaluate their need and potential alternatives, and address them accordingly.

1. Identify yellow-tag targets such as EHS hazards, chemicals and other hazardous materials, and environmental wastes. Also, agree on criteria for evaluating yellow-tagged items.
2. Make and attach yellow tags to identified items and include data to allow for evaluation of performance improvements.
3. Evaluate and address yellow-tagged items.
4. Document results.

By explicitly incorporating EHS issues into all six pillars during 6S inspections, you can eliminate more waste and risk. Inspection checklists and audit questions are powerful tools to sustain 6S improvements and to prompt identification of new improvement opportunities.

Your Thoughts

Now that you have finished this chapter, reflect on what you read by answering these questions:

- What did you learn in this chapter that was particularly useful?
- Do you need any more information to fully understand how to integrate EHS considerations into 6S? Would any other tools be helpful?
- What other ideas do you have to improve the environmental performance of your company with 6S?

Notes:

CHAPTER 6
Conclusion and Implementation Strategies

Chapter Contents

Summary of Key Points in the Toolkit

Lean practitioners have an opportunity to realize greater business value by learning to see and eliminate environmental waste in Lean initiatives.

Environmental wastes, such as pollution and wasted raw materials, can carry large financial burdens, create health and safety hazards, and require time-consuming support activities.

Effective integration of Lean and environmental management efforts can allow organizations to avoid risks from non-compliance with regulatory requirements, as well as to discover new ways to improve operational and environmental performance.

The Lean and environment strategy outlined in this toolkit includes five main components:

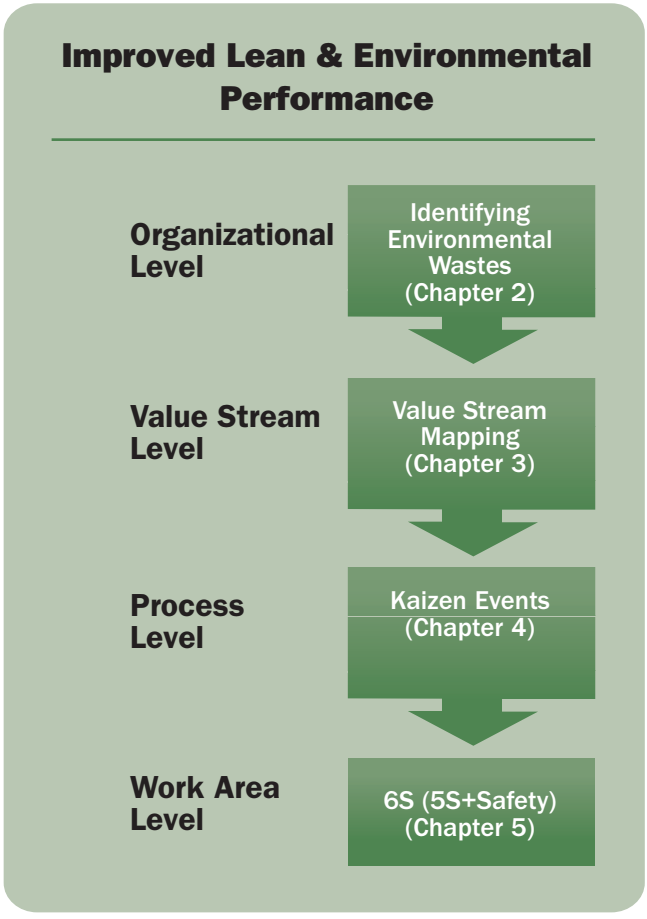
1. Commit to eliminate environmental waste through Lean implementation.
2. Recognize new improvement opportunities by incorporating EHS icons and data into value stream maps.
3. Involve staff with EHS expertise in planning for and implementing Lean events on processes with environmental opportunities.
4. Find and drive out environmental wastes in specific processes by asking key questions and using new process-improvement tools.
5. Empower and enable workers to eliminate environmental wastes in their work areas through training, 6S (5S+Safety) workplace evaluation checklists, and colored tags to identify EHS hazards and issues.

Toolkit Implementation Strategies

So how can you put the ideas in this toolkit to use? While there is no single right way to proceed, lessons from organizations that have successfully bridged their Lean and environmental initiatives provide some implementation strategies that can maximize opportunities for improved Lean and environmental performance. Consider the ideas below and think about how they could be adapted to meet the needs and context of your organization.

1. Begin the Dialogue

If your organization has dedicated personnel who are responsible for Lean implementation and for environmental, health, and safety management, organize a meeting. Even a brief discussion can open the door to identifying shared interests and opportunities for collaboration. Discuss a plan for building a relationship between Lean and environmental improvement efforts over time. Set a tone for collaboration—having Lean and EHS managers working together typically enhances the results of both Lean and environmental initiatives.



2. Cross-Train Lean and EHS Leaders

Taking a few steps to understand each others' language can go a long way. Invite EHS personnel to participate in Lean trainings and events to introduce them to Lean principles and techniques. Periodic meetings between EHS managers and Lean champions or value stream managers can help those involved in Lean efforts better understand when and where to seek EHS technical assistance and how to identify environmental wastes. Mentioning environmental wastes in Lean training presentations is another good initial step (see Chapter 2).

3. Test and Pilot Lean and EHS Integration Techniques

Experiment with one or more of the Lean and EHS integration strategies and tools presented in this toolkit. While it may make sense to start testing techniques at the organizational and value stream levels (see Chapters 2 and 3) to help identify synergies and opportunities, it is possible to experiment with the techniques in this toolkit in almost any order. Start by testing one or two tools in a single event or area of the plant. Evaluate how well they worked. Adapt them to fit into your organizational systems and culture. Move on to experiment with other tools.

4. Scale-Up Lean and Environment Integration

Once you have tested and piloted various techniques for improving Lean and environmental results, adapt and use the techniques throughout your organization. Consider applying Lean methods to improve the performance of EHS functions, ranging from regulatory compliance management and reporting systems to chemical and waste management processes. Explore opportunities to incorporate environmental considerations into Lean process and product design activities. Convene Lean and EHS leaders to discuss other potential areas of collaboration for improving organization results and competitive advantage.

Case Study: 3M Corporation

3M is a leader in the use of Lean Six Sigma methods and tools to improve operations and quality. Lean Six Sigma has been in use at 3M for several years, and in 2001 the company launched a larger, corporate-wide initiative. As of 2006, over 55,000 employees had been trained on Lean Six Sigma processes. 3M EHS managers regard Lean Six Sigma as a vital tool for achieving EHS and sustainability goals. Lean projects have improved operational efficiency and product yield, and also reduced energy use, air emissions, waste and greenhouse gas emissions. Lean Six Sigma is expected to help 3M achieve its 2010 Environmental Goals, which include reducing volatile air emissions by 25 percent and waste by 20 percent, improving energy efficiency by 20 percent, and implementing 800 Pollution Prevention Pays projects.

The Lean and Environment Journey

This toolkit represents the beginning of an exciting journey. As customer and societal expectations around environmental performance and sustainability continue to increase, Lean initiatives offer compelling opportunities to improve both economic and environmental performance. We hope that this toolkit spurs creative thinking and energy within your organization and encourages you to explore these opportunities.

We also hope to learn from your experiences using this toolkit. Working with partner companies and organizations, we aim to periodically release new versions of the Lean and Environment Toolkit. Our hope is to refine the techniques presented, to provide examples and case studies of their application, and to address new techniques not covered.

We wish you success on your Lean and environmental improvement journey.

Your Thoughts on the Toolkit

Now that you have finished this toolkit, reflect on what you read by answering these questions:

- What strategies and tools in the toolkit seemed particularly interesting and useful?
- What steps will you take next to improve Lean and EHS integration at your organization?
- What Lean or other process improvement methods (e.g., TPM, 3P, Six Sigma, policy deployment, etc.) do you think might have good opportunities for improved Lean and environment performance?
- What other information and tools would assist your organization to improve its Lean and environment performance?

Notes:

Appendices

Appendix A

Lean Methods

This appendix provides information on three methods used in Lean production:

- Value stream mapping;
- Kaizen events; and
- 6S (5S+Safety).

Overview of Value Stream Mapping (VSM)

Introduction

Value stream mapping (VSM) is a process mapping method used to document the current and future states of the information and material flows in a value stream from customer to supplier. A value stream is the set of specific actions (value-added and non-value added) required to bring a specific product through three critical management tasks of any business: problem solving, information management, and physical transformation. VSM is used as a communication tool, a business planning tool, and a management tool.

Through VSM, a business process is examined from beginning to end. Each step in the process is included in a drawing that acts as a visual representation of the material and information flows. In other words, an end-to-end system map is created; this is called the current state map. A future state map shows how things should work in order to gain the best competitive advantage. The opportunities for improvement at each step that would have a significant impact on the overall production system are highlighted on the future state map and then implemented, creating a leaner production process.

The key to VSM is to see the big picture as a sum of the parts. Rather than optimizing one part of one step or "fixing something broken," you see how that step fits into the overall production process and how changing it will affect the overall process. This provides the opportunity to visualize how different types of changes, or a combination of changes at multiple places in the process, will affect the entire system. The change, or set of changes, that will result in the most efficient production overall can then be chosen.

The Three Steps to Value Stream Mapping

1. Current State Drawing

The current production system is drawn by first conducting a walkthrough of the entire system from beginning to end. During the walkthrough gather information on the shop floor and analyze the current production system. Then draw a basic overview map with process and material flows represented by different symbols on the map. A set of existing symbols can be used or a new set created, but the method of mapping should always be kept consistent within the company to gain better staff understanding and awareness. After the basic production process is understood, more detail is added to the map at each process step creating a comprehensive picture of the current system.

2. Future State Drawing

Future state ideas will likely arise while gathering information in the first step. You can either keep a running list of these ideas and turn them into a future state map after you have completed the current state map, or draw the future state map alongside the current state map. A key to creating a more Lean future state is identifying areas of overproduction and root causes of waste in the current production system, and finding ways to reduce or eliminate them in the future system. The idea behind creating a Lean value stream is to create only what is needed when it is needed. A few ways to help accomplish this are to use *takt* time (the rate of customer demand) to synchronize the pace of production with the pace of sales, develop a continuous flow, and level the production mix. More details on how to Lean the value stream can be found in the resources below.

3. Work Plan and Implementation

In this step, a work plan is prepared based on the future state value stream map that describes specific ways in which the future state map will be achieved. VSM is a tool to identify areas that need improvement in the value stream. By itself, VSM will not produce the desired change; implementation is key to achieving results. Implementation is usually best done in stages since the entire system is affected. One way of doing this is to break the future state map into segments or loops, and implement changes within one loop at a time. The work plan should also include measurable goals and checkpoints. Once the work plan is implemented a new, more efficient current state is formed. To keep continuous improvement happening in your business, once a future state becomes a new current state, a new future state map should be drawn, and the cycle continued. An annual value stream review is a good way to keep things moving.

Case Study: Canyon Creek

The Washington State Department of Ecology and Washington Manufacturing Services partnered in a Lean and environment pilot project to provide technical assistance to Canyon Creek Cabinet Company. Project participants formed two teams to address Canyon Creek's Millennia cabinet line, along with plant-wide milling and cutting operations, and its finishing department. The teams used value stream mapping to identify improvement activities and conducted three week-long kaizen events to implement the changes. These process improvements decreased lead times, work-in-process, defects, overproduction, operator travel time, and material loss and damage. The company's hazardous and solid wastes, wastewater discharges, energy consumption, and volatile organic compound emissions were also reduced. Canyon Creek expects to save $1.56 million due to the Lean and environment changes that were implemented during the kaizen events.

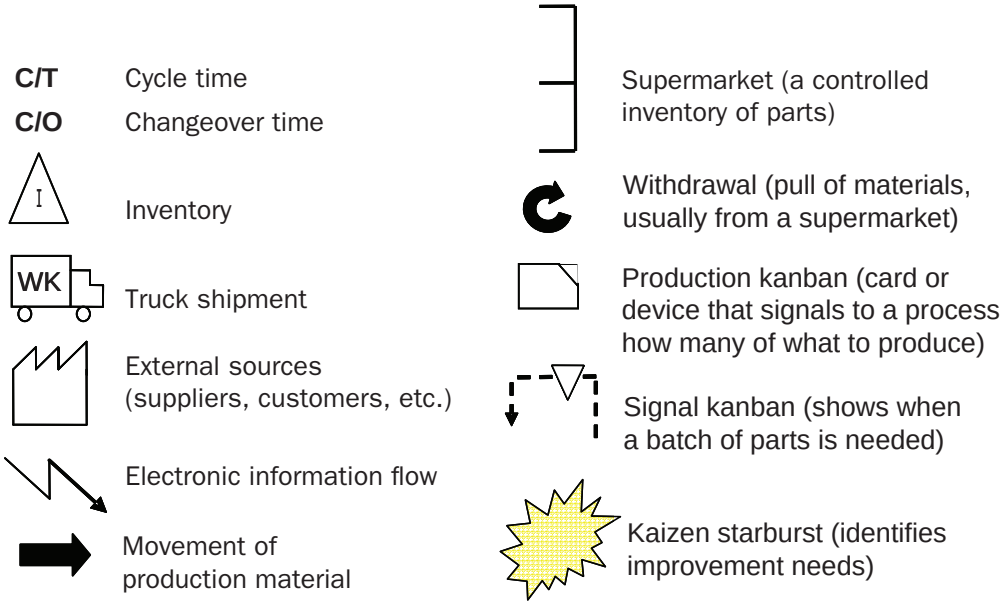
Additional Resources

Rother, Mike and John Shook. Learning to See: Value-Stream Mapping to Create Value and Eliminate Muda. Brookline, MA: Lean Enterprise Institute, Inc., 2003.

Tapping, Don, Tom Luyster, and Tom Shuker. Value Stream Management: Eight Steps to Planning, Mapping, and Sustaining Lean Improvements. New York, NY: Productivity Press, 2002.

Common Icons Used in Value Stream Maps

Here is a key to Lean symbols used in the value stream maps in this toolkit.



Overview of Kaizen Events

Introduction

Kaizen means continual improvement and is taken from the Japanese words *kai*, meaning "to take apart" and *zen*, meaning "to make good." Kaizen is based on the fundamentals of taking something apart and understanding how it works so that it can be made better. There is a focus on eliminating waste, improving productivity, and achieving sustained continual improvement in targeted activities and processes of an organization. Kaizen is built on the philosophy that small, incremental changes routinely applied and sustained over a long period result in significant improvements overall.

Kaizen events, also known as rapid process improvement events, are a team activity designed to eliminate waste and make rapid changes in the workplace through the targeted use of Lean methods. The strategy aims to involve workers from multiple functions and levels in the organization in working together to address a problem or improve a process. The team uses process improvement methods, such as cellular manufacturing and Total Productive Maintenance, to identify opportunities quickly to eliminate waste in a targeted process or production area. The team also works to implement chosen improvements rapidly (often within 72 hours of initiating the kaizen event), typically focusing on solutions that do not involve large capital outlays.

The philosophy of kaizen is often considered to be the "building block" of all Lean production methods. Kaizen's impressive results often stem from:

- Kaizen's focus on moving rapidly from planning to implementation;
- Kaizen's focus on making continued progress rather than waiting to find the perfect solution;
- Kaizen's focus on worker involvement and team work;
- Kaizen's focus on addressing the root causes of problems; and
- Kaizen's focus on process improvement from a systems perspective.

The Three Phases of a Kaizen Event

Kaizen events typically require an organization to foster a culture where employees are empowered to identify and solve problems. Most organizations implementing kaizen-¬type improvement processes have established methods and ground rules that are well communicated in the organization and reinforced through training. Kaizen events generally have three main phases, although organizations can adapt and sequence these activities to work effectively in their unique circumstances.

Phase 1: Planning and Preparation

To prepare for a kaizen event, a target area and problem are selected. Such areas might include: areas with substantial work-in-progress (WIP); an administrative process or production area where significant bottlenecks or delays occur; and/or areas that have significant market or financial

impact (i.e., the most "value added" activities). A more specific "waste elimination" problem within that area is then chosen for the focus of the kaizen event. Baseline information is collected for the process area and improvement targets and measures are established. An event leader and a team are carefully selected and trained, making sure to tap a range of expertise, including shop floor workers who are intimately familiar with the targeted process.

Phase 2: Implementation—The Event

Implementation focuses on the actual kaizen event, lasting from two to five days, depending on their scope. The facilitated events emphasize worker participation. The first part of an event includes a kick-off and an assessment of the current state of the targeted process and problem so that all team members have a similar understanding of the problem they are working to solve. This part frequently involves process observation, data collection, and process mapping. Team members are assigned specific roles for research and analysis. As more information is gathered, team members add detail to value stream maps of the process and conduct time studies of relevant operations (e.g., cycle time, lead time). The next part focuses on developing, selecting, implementing, and testing improvement ideas. Team members identify and record all observed waste, by asking what the goal of the process is and whether each step or element adds value towards meeting this goal. Once non-value added activity is identified and measured, team members then brainstorm improvement options. Ideas are often tested on the shop floor or in process mock-ups. The most promising ideas are selected and implemented.

Phase 3: Presentation and Follow-up

Wrap-up and follow-up activities ensure that the results of a kaizen event are communicated and sustained in the organization. Improvements made during an event must be shared with others in the organization, particularly with those affected by changes to standard work. Celebration is also important to recognize team member contributions and to cultivate a culture of worker involvement. Follow-up activities to measure process performance, make adjustments, and ensure that unresolved actions are completed are critical to prevent backsliding.

Additional Resource

Productivity Press Development Team. *Kaizen for the Shopfloor*. Portland, OR: Productivity Press, 2002.

Overview of 6S (5S+Safety)

Introduction

6S is modeled after the 5S process improvement system designed to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results. It derives from the belief that, in the daily work of a company, routines that maintain organization and orderliness are essential to a smooth and efficient flow of activities. Implementation of this method "cleans up" and organizes the workplace basically in its existing

configuration. It is typically the starting point for shop-floor transformation. The 5S pillars, *Sort, Set In Order, Shine, Standardize, and Sustain*, provide a methodology for organizing, cleaning, developing, and sustaining a productive work environment. 6S uses these five pillars plus an added pillar for Safety. 6S encourages workers to improve the physical setting of their work and teaches them to reduce waste, unplanned downtime, and in-process inventory.

The 6S Pillars

Sort. The first pillar focuses on eliminating unnecessary items from the workplace that are not needed for current production operations. An effective visual method to identify these unneeded items is called "red tagging," which involves evaluating the necessity of each item in a work area and dealing with it appropriately. Organizations often find that sorting enables them to reclaim valuable floor space and eliminate such things as broken tools, scrap, and excess raw material.

Set in Order. This pillar focuses on creating efficient and effective storage methods to arrange items so that they are easy to use and to label them so that they are easy to find and put away. Set In Order can only be implemented once the first pillar, Sort, has cleared the work area of unneeded items. Strategies for effective Set in Order include affixing labels and placards to designate proper storage locations and methods, outlining work areas and locations, and installing modular shelving and cabinets.

Shine. Once the clutter that has been clogging the work areas is eliminated and remaining items are organized, the next step is to thoroughly clean the work area. Daily follow-up cleaning is necessary to sustain this improvement. Working in a clean environment enables workers to notice malfunctions in equipment such as leaks, vibrations, breakages, and misalignments that could lead to loss of production. Organizations often establish Shine targets, assignments, methods, and tools before beginning the Shine pillar.

Safety. This pillar focuses on eliminating hazards and creating a safe environment to work in. Once the workplace has been organized and cleaned, potential dangers become easier to recognize. A separate "safety sweep" should be performed to identify, label, and deal with hazards; however, safety measures can also be implemented in conjunction with strategies in the other five pillars (for example, yellow (safety) tagging can be done at the same time red tagging takes place).

Standardize. This pillar is used to maintain the first three pillars, creating a consistent approach with which tasks and procedures are performed. The first steps are to assign 6S (Sort, Set in Order, Shine) job responsibilities and integrate 6S duties into regular work duties. Some of the tools used to accomplish this are: job cycle charts, visual cues (e.g., signs, placards, display scoreboards), and check lists. The second part of Standardize is prevention—preventing accumulation of unneeded items, preventing procedures from breaking down, and preventing equipment and materials from getting dirty.

Sustain. This pillar makes a habit of properly maintaining correct procedures and is often the most difficult pillar to implement and achieve because changing entrenched behaviors can be difficult. Sustain focuses on defining a new status quo and standard of work place organization. Without the Sustain pillar the achievements of the other pillars will not last long. Tools for sustaining 6S include signs and posters, newsletters, pocket manuals, team and management check-ins, performance reviews, and department tours.

When the six pillars have been implemented and organizational and safety procedures are maintained, the workplace becomes a safer and more efficient place to work leading to increased productivity and worker confidence. Although other Lean methods can be used without using 6S, the 6S method creates a streamlined workplace and a good base which can often times enhance the results from other Lean processes.

Additional Resources

Hirano, Hiroyuki. *5 Pillars of the Visual Workplace*. Portland, OR: Productivity Press, 1995.

Peterson, Jim, Roland Smith, Ph.D. *The 5S Pocket Guide*. Portland, OR: Productivity Press, 1998.

Productivity Press Development Team. *5S for Operators: 5 Pillars of the Visual Workplace*. Portland, OR: Productivity Press, 1996.

Productivity Press Development Team. *5S for Safety Implementation Toolkit: Creating Safe Conditions Using the 5S System*. Portland, OR: Productivity Press, 2000.

Productivity Press Development Team. *5S for Safety: New Eyes for the Shop Floor*. Portland, OR: Productivity Press, 1999.

Appendix B

Basic Environmental Measures for Lean Enterprises

The following facility-level draft of basic environmental measures could help world-class Lean practitioners document:

- The cost benefits from integrated approaches to managing/preempting environmental risks and liabilities;
- The environmental benefits of life cycle approaches that seek synergies from investments into cleaner technologies and the production of green products/services;
- The use of pollution prevention as a tool to a sustainable future by augmenting the Lean system's capacity through the systematic elimination of environmental hazards and pollution sources; and
- The quantities of chemicals, water and energy impacts, and environmental discharges being reduced or eliminated.

These metrics can be incorporated into current manufacturing processes seamlessly as they are directed at the same goals as the business part: waste reduction.

Disclaimer

The draft basic environmental measures below should not be construed as an exhaustive list of environmental performance measures since other investment, efficiency, effectiveness, cost/benefit activities, and behavioral level measures may not be currently measured by this tool. These other facility-level environmental outcome measures may be compelled, however, by environmental management systems that are ISO 14000 compliant. Likewise, other voluntary EPA or state environmental pollution prevention partnerships may compel a level of documentation beyond the one sought by the enclosed performance measurement tool.

EPA's Lean and Environment Basic Environmental Measures

The basic environmental measures tool below is in part derived from two EPA national voluntary partnership programs—the Green Supplier Network and the National Environmental Performance Track. The measures include priority chemicals that are of particular concern because of their toxicity, persistence in the environment, and/or their potential to bioaccumulate in organisms at higher levels in the food chain.

Many leading enterprises already report the environmental performance measures identified in this table to national and state environmental reporting systems such as the Toxics Release Inventory and voluntary environmental partnership programs.

Basic Environmental Measures			
Category	**Definition**	**Metric**	**Unit of Measure**
Input Measures			
Energy Use	Any source providing usable power or consuming electricity Transportation and non-transportation sources	Energy Used	Specific to energy source such as BTUs or kilowatt hours, % reduction, energy use/unit of product
Land Use	Land covered by buildings, parking lots, and other impervious surfaces Land/habitat conservation	Land Converted, Land Restored or Protected, Area of Impervious Surfaces	Square feet, acres
Materials Use	Materials used (total or specific), ex. packaging materials Proportion of input materials that were recycled or recovered (vs. virgin materials)	Materials Used, Percent Utilization of Materials, Post-Consumer Recycled Content	Tons/year, pounds/unit of product, % materials utilization
Toxic/ Hazardous Chemicals Use	Use of hazardous and toxic chemicals that are regulated or are otherwise of concern http://www.epa.gov/epaoswer/hazwaste/minimize/chemlist.htm	Toxic/Hazardous Chemicals Used	Pounds/year, pounds/unit of product, % reduction
Water Use	Incoming raw water, from outside sources, e.g., from municipal water supply or wells, for operations, facility use, and grounds maintenance.	Volume of Water Used, P2 to reduce Priority Chemicals/ Quality Standards/Pretreat Standards	Gallons/year, % reduction, % recycled Pounds Priority Chemicals/year, % reduced, % recycled
Non-Product Output Measures			
Air Emissions	The release of any of the following: Air toxics—CAA 112b HAPs Carbon Monoxide Lead Ozone and its precursors, including: VOCs (volatile organic compounds) NO_x (nitrogen oxides) Ozone-depleting substances PM10 (particulate matter) PM2.5 (fine particulate matter) Sulfur Dioxide Greenhouse gases, including Carbon Dioxide	Air Emissions Generated	Pounds/year, Tons/year % reduction

Basic Environmental Measures (Continued)			
Category	**Definition**	**Metric**	**Unit of Measure**
Non-Product Output Measures			
Water Pollution	Quantity of pollutant in wastewater that is discharged to water source. Should include any substances regulated in NPDES permit. May include: Heavy Metals - Cu, Pb, Hexavalent Chromium, Cadmium, Zn, Ni, Hg, Organic Pollutants and Pesticides, Conventional pollutants, e.g., oil and grease, BOD and suspended solids, and Nutrients - N, P Pathogens Sediment from runoff Wastewater discharge volume	Mass or Concentration of Regulated Pollutants Discharged	Pounds/year, mg/L or % reduction
Solid Waste	Wastes (liquid or solid) other than RCRA hazardous wastes.	Solid (Non-Hazardous) Waste Generated	Gallons or pounds/year, % reduction, % recycled
Downstream/Product Measures			
Product Impacts	Expected lifetime energy and water use Wastes (to air, water, & land) from product use and disposal or recovery		Energy—BTU, kWh, mWh Water use–gallons Wastes–pounds, tons
Other Measures			
Money Saved	Money saved in the reduction of materials or other changes in processes	Dollars saved	Dollars saved
Qualitative Measures	Other environmental improvements that cannot be directly or accurately quantified. For example: implementing an EMS		Savings and environmental benefits from leaning out of permits/ Design for Environment/ Clean Production/ EMS implementation/ Extended Product Responsibility

Appendix C Lean Event EHS Checklist

Lean Event Checklist for EHS Impacts		
1. Title of Lean Event		2. Organziation/Department
3. Date	4. Building/Process Affected	
5. Lean Team Leader	6. Phone number	7. E-mail Address

*To ensure that changes proposed during Lean events identify potential environmental compliance, health, safety, and/or fire protection impacts, this form **must** be completed by the team leader for all organizations undergoing Lean activities.*

Background Information: Impacts (either positive or negative) could occur as a result of altering chemicals/materials use, the location of the process, or facility alterations. Any potential impacts must be addressed prior to implementing any changes. Potential changes that must be identified on this form include:

- Changes to the type, volume, or introduction/issuance procedure for chemicals and materials use, the location of the process, or facility exposure. This may change the procedure for gathering data to report to regulatory agencies.
- Changes to the type of volume of waste generated by a process. This includes all media such as air emissions, water emissions, liquid/solid waste, etc.
- Changes proposed to either the physical layout of the process (i.e., moving work or storage areas) or to the facility (moving, replacing, or installing items such as vent hoods, floor drains, stacks, or process tanks).

Instructions: Describe the Lean event/process and answer the following questions about proposed process changes. If any of the questions are answered either "Yes" or "Unk" (unknown), there may be the potential for environmental impacts that need to be reviewed by EHS staff. Please contact _____ immediately upon identification of potential impacts or with questions.

Physical Environment			
As a result of the Lean event, will there be:	**Unk**	**Yes**	**No**
Any changes to the locations where either maintenance work or use of hazardous chemical/material will occur?			
Any changes to your personnel's work zone assignments?			
Any new equipment or modifications to existing equipment, or movement of existing equipment that has the potential to produce air or water emissions (e.g., rinse equipment/operations, cleaning tank, heating ovens)?			
Any changes to the facility (e.g., vents, stacks, floor drains, oil/water separators)?			
Any changes in the location(s) of the current flammable storage locker/areas?			
Any new confined space entry activities or procedures (e.g., personnel entering fuel tanks for cleaning)?			
Material/Chemical Use and Storage			
As a result of the Lean event, will there be:	**Unk**	**Yes**	**No**
Any changes to the type or volume of materials issued to personnel and/or used? This includes the introduction of new chemicals, elimination of chemicals, etc.			
Any changes to the chemical introduction or issuance procedure for chemicals/materials containing hazardous materials?			
Any changes in the volume of chemicals/materials stored?			
Any flammable materials that are not returned to the storage cabinets at the end of each shift?			
Waste Management			
As a result of the Lean event, will there be:	**Unk**	**Yes**	**No**
Any change(s) to the waste profiles for wastes stored at any initial accumulation points?			
Any change(s) to the location or number of initial waste accumulation points?			
Any change(s) to the volume of waste(s) that require disposal (i.e., wastewater, hazardous or solid waste) or to the volume of material that will be recycled or reused?			

Appendix D

Pollution Prevention Resources

General Sources of Information

Pollution Prevention (P2) Information from the U.S. Environmental Protection Agency

http://www.epa.gov/p2/

This comprehensive site includes information organized for different P2 audiences, programs, concepts, and product stages. It contains numerous links to databases, tools, publications, funding opportunities, and regional programs.

Pollution Prevention Resource Exchange (P2Rx)

http://www.p2rx.org/

P2Rx is a national network of regional information centers and resources on pollution prevention including breaking news, research and publications, and regional and national networking opportunities.

Pollution Prevention Information Clearinghouse (PPIC)

http://www.epa.gov/opptintr/library/ppicindex.htm

PPIC is a free information service of EPA dedicated to reducing and eliminating industrial pollutants through technology transfer, source reduction, education and public awareness. The site contains links to EPA documents and fact sheets as well as external P2 websites, an archive of older P2 documents, conference listings, and a reference and referral service.

Pollution Prevention Regional Information Center

http://www.p2ric.org/TopicHubs/toc.cfm?hub=26&subsec=7&nav=7

The Topic Hub™ for Pollution Prevention acts as a primer on pollution prevention, providing background information and resources on P2 principles, opportunities, and incentives. There is also a compilation of online resources listed by resource type including audio/visual, handbooks, fact sheets, and case studies among others.

The National Waste Minimization Program

http://www.epa.gov/wastemin/

This EPA program supports efforts that promote a more sustainable society, reduce the amounts of waste generated, and lower the toxicity and persistence of wastes generated. In order to attain a sustainable future, this program advocates the use of advanced production and management tools including lean manufacturing, chemical management services, greening the supply chain, and waste-to-energy technologies. In addition, this program spearheads The National Partnership for

Environmental Priorities Program (NPEP), which showcases success stories regarding flexible, yet protective, ways to reduce priority chemicals as well as conserve our natural resources.

Joint Service Pollution Prevention Technical Library

http://p2library.nfesc.navy.mil/

This site provides links to documents, fact sheets, presentations, data sheets, and other web links on pollution prevention opportunities and general pollution prevention resources. It also provides links to documents issued by specific Federal agencies, non-Federal government, and other organizations.

Pollution Prevention Assistance Division, Georgia Department of Natural Resources

http://www.p2ad.org

This site provides "free, non-regulatory, and confidential technical assistance in the areas of pollution prevention, resource conservation, waste reduction, by-product reuse and recycling." There are links to resources for industry, business, government, agriculture, and the general public.

Canada Pollution Prevention Information Clearinghouse

http://www.ec.gc.ca/cppic/en/index.cfm

Search over 1,200 pollution prevention references ranging from fact sheets to case studies. References are searchable by keyword and by specific industrial sector.

Regional Resources

- Great Lakes Regional Pollution Prevention Information Center (IL, IN, MI, MN, NY, OH, PA, WI, and Ontario, Canada), http://www.glrppr.org/
- Northeast Waste Management Officials' Association (CT, MA, ME, NH, NJ, NY, RI, and VT), http://www.newmoa.org/
- Pacific Northwest Pollution Prevention Resource Center (WA, ID, OR, and AK), http://www.pprc.org/
- Peaks to Prairies Pollution Prevention Information Center (CO, MT, ND, SD, UT, and WY), http://peakstoprairies.org/
- Pollution Prevention Regional Information Center (IA, KS, MO, and NE), http://www.p2ric.org/
- Southwest Network for Zero Waste (AR, LA, NM, OK, and TX), http://www.zerowastenetwork.org/
- Waste Reduction Resource Center (AL, DC, DE, FL, GA, KY, MD, MS, NC, PA, SC, TN, VA, and WV), http://wrrc.p2pays.org/
- Western Regional Pollution Prevention Network (AZ, CA, HI, and NV), http://www.wrppn.org/

Appendix E 6S Safety Audit Checklist

Document Title: 6S Audit Record (Safety)	Document No.	
	Revision No.	Page: 1 of: 4
Required by:		

Audit Type:

☐ Initial Certification

☐ Sustaining

Auditors: Date: _____

Name: _____ Name: _____

_____ Workplace Representatives:_____

Name: _____ Name: _____

Subject	Questions	Yes	No
1. Aisles	**A.** Are aisles marked? 29 CFR 1910.22(b)(2)		
	B. Are aisle widths maintained? 29 CFR 1910.22(b)(1)		
	C. Are aisles in good condition? 29 CFR 1910.22(b)(1)		
	D. Are aisles and passageways properly illuminated?		
	E. Are aisles kept clean and free of obstruction? 29 CFR 1910.22(b)(1)		
	F. Are fire aisles, access stairways, and fire equipment kept clear? 29 CFR 1910.178(m)(14)		
	G. Is there a safe clearance for equipment through aisles and doorways? 29 CFR 1910.176(a)		
2. Chemicals	**A.** Are all hazardous chemicals appropriately labeled? 29 CFR 1910.1200(f)(5); 29 CFR 1910.1200(f)(6)		
	B. Are workers nearby aware of the content of chemical piping systems? 29 CFR 1910.1200(e)(1)(ii); 29 CFR 1910.1200(f)(5); 29 CFR 1910.1200(f)(6)		
	C. Is there a list of hazardous substances used in your work area? 29 CFR 1910.1200(e)(1)(l)		
	D. Is there a material safety data sheet readily available for each hazardous substance used? 29 CFR 1910.1200(g)(9); 29 CFR 1910.1200(g)(10)		

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Subject	Questions	Yes	No
3. Electrical	**A.** Do extension cords being used have a grounding conductor? 29 CFR 1910.1200(f)(5); 29 CFR 1910.304(f)(5)(v); 29 CFR 1910.334(a)(3)		
	B. Is sufficient assess and working space provided and maintained about all electrical equipment to permit ready and safe operations and maintenance? 29 CFR 1910.303(g)(1); 29 CFR 1910.303(h)(3)		
	C. Are all cord and cable connections intact and secure? 29 CFR 1910.305(g)(2)(iii)		
	D. Are all disconnecting means legibly marked to indicate their purpose, unless located so that their purpose is evident? 29 CFR 1910.303(f)		
	E. Are flexible (extension) cords and cables free of splices or taps? 29 CFR 1910.305(g)(2)(ii)		
4. Exits	**A.** Are exits properly marked? 29 CFR 1910.37(q); 29 CRF 1910.37(H)		
	B. Are exits kept free of obstruction? 29 CFR 1910.36(d)(1)		
	C. Are the directions to exits, when not immediately apparent, marked with visible signs? 29 CFR 1910.37(q)(5)(6)		
	D. Are doors, passageways or stairways that are neither exits nor access to exits and which could be mistaken for exits, appropriately marked “NOT AN EXIT” “TO BASEMENT,” “STOREROOM,” etc.?		
5. First Aid	**A.** Do you have emergency eye wash and shower facilities within the immediate work area where employees are exposed to injurious corrosive materials? 29 CFR 1910.151(c)		
	B. Do you have first-aid kits easily accessible to each work area, with necessary supplies available, periodically inspected and replenished as needed? 29 CFR 1910.151(b)		
	C. Are emergency phone number posted where they can be readily found in case of an emergency? 29 CFR 1910.38(a)(2)(v)(vi)		

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Subject	Questions	Yes	No
6. Flammable/ Combustible Containers	**A.** Are approved containers and portable tanks used for the storage and handling of flammable and combustible liquids? 29 CFR 1910.106(d)(2); 29 CFR 1910.144(a)(1)(ii)		
	B. Are safety cans used for dispensing flammable or combustible liquids at a point of use? 29 CFR 1910.106(d)(5)(iii)		
	C. Are storage cabinets used to hold flammable liquids, labeled "Flammable – Keep Fire Away"? 29 CFR 1910.106(d)(3)(ii)		
7. Forklift Operations	**A.** Are all industrial trucks not in safe operating condition removed from service? 29 CFR 1910.178(q)(1)		
	B. Are your forklifts inspected before being placed in service? Inspections should be at least daily, or after each shift, if used around the clock. 29 CFR 1910.178(q)(7)		
	C. Are industrial trucks equipped with flashing lights, horn, overhead guard, and name plate (load limits)? 29 CFR1910.178(a)(2)		
8. Hazardous Waste Management	**A.** If your operations generate waste from oil or grease, do you handle it in an approved manner? 40 CFE 279.22		
	B. If your operations generate waste from fluorescent light bulbs, do you handle it in an approved manner? 40 CFR 273.14(e)		
	C. If your operations generate hazardous waste, do you handle it in an approved manner according to 40 CFR 262?		
9. Hearing Conservation	**A.** Are workers protected from sources of excessive noise? 29 CFR 1910.95(a)		
	B. Is approved hearing protective equipment available?		
10. Housekeeping	**A.** Are work areas clean? 29 CFR 1910.95(i)(1); 29 CFR 1910.141(a)(3)		
	B. Are mats, grating, etc. used where drainage is needed?		
	C. Is the compressed air for cleaning less than 30 psi?		
	D. Are work surfaces kept dry or are appropriate means taken to assure the surfaces are slip-resistant?		
	E. Are all spilled materials or liquids cleaned up immediately?		

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Subject	Questions	Yes	No
11. Lockout	**A.** Is all machinery or equipment capable of movement, required to be de-energized or disengaged and locked out during cleaning, servicing, adjusting or setting up operations, whenever required? 29 CFR 1910.147(c)(1); 29 CFR 1910.147(c)(2)(I)		
	B. Are correct lockout/tagout procedures in use? 29 CFR 1910.147(c)(4); 29 CFR 1910.147(d); 29 CFR 1910.147(e)		
	C. Are suspended loads or potential energy (such as compressed springs, hydraulics or jacks) controlled to prevent hazards? 29 CFR 1910.147(d)(5)		
12. Machine Guarding: General	**A.** Are rotating or moving parts of equipment guarded to prevent physical contact? 29 CFR 1910.212(a)(1); 29 CFR 1910.219(F)		
	B. Are all moving chains and gears properly guarded? 29 CFR 1910.219(f)(1); 29 CFR 1910.219(f)(2)		
	C. Are machinery guards secure and so arranged that they do not offer a hazard in their use? 29 CFR 1910.212(a)(2)		
13. Machine Guarding: Portable Power Tools	**A.** Are grinders, saws, and similar equipment provided with appropriate safety guards? 29 CFR 1910.243(a)(1); 29 CFR 1910.243(c)(1)-(4); 29 CFR 1910.243(e)(1)(I)		
	B. Are power tools used with the correct shield, guard, or attachment recommend by the manufacturer?		
14. Machine Guarding: Stationary Equipment	**A.** Is fixed machinery provided with appropriate safety guards to prevent injuries to the operator and other employees resulting from point of operation, in-going nip point, rotation parts, flying chip, and spark hazards? 29 CFR 1910.212(a)(1)		
	B. Are foot-operated switches guarded or arranged to prevent accidental actuation by personnel or falling objects? 29 CFR 1910.217(4)		
	C. Is there a power shut-off switch within reach of the operator's position at each machine? 29 CFR 1910.213(b)(1)		
	D. Are fan blades protected with a guard having openings no larger than ½ in., when operating within 7ft of the floor? 29 CFR 1910.212(a)(5)		

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Subject	Questions	Yes	No
15. Personal Protective Equipment	**A.** Are all employees required to use personal protection equipment (PPE) as needed? 29 CFR 1910.132(a)		
	B. Is PPE functional and in good repair? 29 CFR 190.132(e)		
	C. Are all employees required to use personal protective equipment (PPE) when handling chemicals (gloves, eye protection, respirators, etc.)? 29 CFR 1910.132(a)		
16. Extinguishers	**A.** Are appropriate fire extinguishers mounted located and identified so that they are readily accessible (not obstructed) to employees? 29 CFR 1910.157(c)(1)		
	B. Are all fire extinguishers inspected monthly and serviced annually, and noted on the inspection tag? 29 CFR 1910.157(e)		
17. Walkways	**A.** Are pits and floor openings covered or otherwise guarded? 29 CFR 1910.22(c); 29 CFR 1910.23(a)		
18. Compressed Gases	**A.** Are compressed gases properly stored and used? 29 CFR 1910.253(b)(1)-(5)		
	B. Are compressed gas cylinder storage rules posted in the storage area?		
19. Work Environment	**A.** Are all work areas adequately illuminated?		
	B. Are combustible scrap, debris, and wastes stored safely and removed from the work site promptly? 29 CFR 1910.141(a)(4)(ii)		

Source: Cash Powell Jr. and Steve Hoekzema. "5S at Deceuninck North America's Monroe Site: Sustaining and Improving the Gains," *Target—Innovation at Work: The Periodical of the Association of Manufacturing Excellence.* Volume 21, Number 3, Third Issue 2005, pp. 32-35.

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