5-S AND THE FACILITY REDESIGN FOR A CLEANING PRODUCTS MANUFACTURING COMPANY

by

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Abstract

This project deals with a “green” cleaning products company in Southern California. Business has increased 38% in the past year along with changes in production capacity and capability, so the company has identified a need for a sustainable model of manufacturing at their new and expanded facility. Goals of promoting sustainable waste management, minimizing types of lean waste, properly storing inventory, improving workplace communication, and defining production tasks will be addressed in this facilities redesign through 5S. The biggest component and outcome of the facility design will be organization. This leads to a goal of eliminating waste, which will in turn promote sustainable manufacturing practices. Further described in the Design chapter, the 5-S implementation looks at waste reduction and/or removal, so areas of the facility will be compared and judged accordingly. Each of the four areas mentioned in design will have been affected at least one component of 5S, especially the areas of standardization and sorting. In addition, methods for continuous improvement will allow opportunities for employees to be accountable with each other, management, and the environment. The project can be justified with or without labor reduction, considering the fact that the new proposal recommends removing five workers. The number of Raw material storage areas went down by two and the number of Finished Goods storage locations went down by three. The recycling/waste management program solely can justify this project, producing an NPV = $59155.70 over ten years, while promoting recycling, reducing, reusing, and rethinking.

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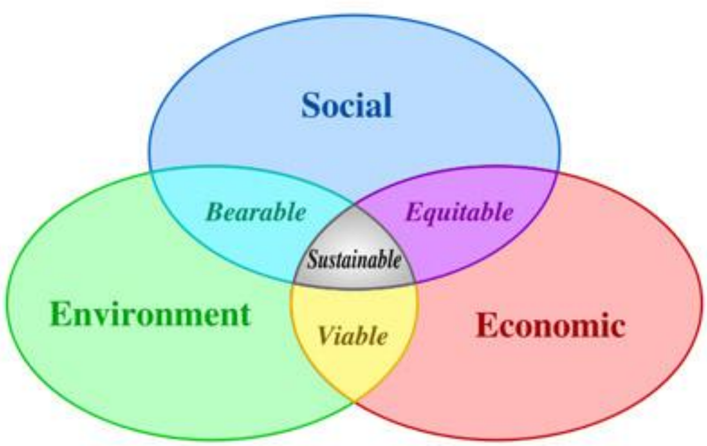
Introduction

Rockwell Automation has noted that manufacturers who adopt sustainable production practices turn marketplace challenges into advantages[1]. These production practices can go beyond even making sustainable products or having “green” slogans, where they become a motto and philosophy of a company. Perhaps the most critical area to facilitate sustainable manufacturing is the production facility itself. This project covers a facility redesign for a green cleaning products company in Garden Grove, California who values environmental care and sustainability. They are expanding their operations into a new building and desire an effective and environmentally conscious production setting. In terms of goals for such a production facility, Rockwell further defines sustainable production as cleaner, safer and more energy efficient operations[2]. Beyond the motive to simply save water or save trees, the ability to maintain a safe, productive, and sustainable production facility depends on the facility layout, ergonomics, economics, and quality. An important theme to remember is where sustainability lies; the intersection of social concerns, economic success, and care for environmental impact the company displays as seen in the following diagram.



Triple Bottom Line[3]

Furthermore, industry leaders view safety and ergonomics as a priority on their sustainability agendas because it is simply not possible to have a sustainable operation if you do not take care of your people and have systems that are designed to enhance productivity and safety[4]. A facility resign is no doubt comprehensive and complex, but the overarching goal of sustainability should provide ergonomic changes, facilitate lean manufacturing implementation, and address quality control issues with a reasonable benchmarks and goals. Utilizing these philosophical foundations and through implementing 5S the company hopes to:

- Optimize facility layout
- Evaluate waste management
- Incorporate opportunities for Kaizen and Visual Controls
- Consider company goals for productivity and sustainability

Thus, the goal becomes improving facility organization while promoting sustainable, efficient production processes through 5-S. While the project is intended to be economically justifiable, many qualitative goals from the company will affect the solution

Background

The cleaning products company bases its operations in Garden Grove, CA. It has international distribution of a retail line of over 60 household products, an industrial/bulk line of over 25 products, and a natural pet care line of 16 items[5]. As mentioned in the introduction, this company has expanded their current facility. Business has increased along with production capacity and capability, so the company has identified a need for a sustainable model of manufacturing at their new and expanded facility. The entire production process occurs at this plant, from coordinating inbound raw materials, ending with outbound customer shipments. The company utilizes several assembly lines after mixing raw chemicals, and puts the finished product in various bottles types for the vast majority of their revenue. A statement on the company websites shares that manufacturing and products done in a responsible manner that safeguards the earth, and products that are never tested on animals[6]. The company further comments that they are committed to living the ecologically friendly lifestyle, and helping others do the same[7]. Because the company is environmentally conscious, they are seeking to make their new facility environmentally "friendly" and to reduce their carbon footprint while modeling sustainability for their company. Goals of promoting sustainable waste management, minimizing waste, properly storing inventory, improving workplace communication, and defining production capabilities will be addressed in this facilities redesign.

Literature Review

This literature review looks at several relevant topics related to facility design, planning, and management. While many issues exist for consideration in such a project, the topics chosen represent modern business, social, and environmental concerns, as well as practical ideas from industrial engineering. An overview of the goals of facility design compiled from several textbooks serves as a foundation, which leads into the practices of sustainability and lean manufacturing. These broad topics are also further broken down into ergonomic improvements at the facility, quality control methods for production and for management, and economic consequences of any implementation.

Facility Design

The trends toward more globalization and outsourcing and the emphasis on facility sustainability may have provided solutions to some problems but also raised further challenges[8]. In Facilities Logistics, the author points out several area of importance in the facility redesign. First, visibility creates total knowledge of the status and plans for every resource and item that in the facility[9]. Second, flexibility in facilities allows preparation for and adjustment to change by utilizing plans, resources, people, and products that are adaptable and scalable[10]. Third, facility and labor management should be driven by a culture of responsibility and self-improvement to support the goals of the facility and its customers[11]. Finally, green and sustainable facilities are energy efficient, support reuse, and minimize the waste stream[12]. The author notes that these bullet points may overlap at times because a comprehensive facility design must evaluate the system components together in the optimal solution.

When considering the layout of a facility, it is evaluated based on its ability to guarantee the reward of relationships between departments required to meet demand requirements, while minimizing the costs associated with storing and handling materials within the facility[13]. Nearly all of the literature on facility redesigns recognizes this importance of an interconnected systems view. Several potentially optimal layout considerations exist, each dependent on the product type and production volume. The authors of Facilites Planning and Design explain that fixed-position layouts have material or major components brought together in a fixed location and product layouts have low numbers of part types and high production volumes[14]. In addition, cellular layouts can handle medium numbers of part types and medium production volumes and process layouts can handle high numbers of part types but low production volumes. The cleaning products company would likely use several different layouts for the different capabilities of the production lines.

Sustainability & Lean Manufacturing

Much of the literature regarding modern facility design looks at sustainability, both environmentally and economically. Most importantly for a company-supported effort, employees need to play a clear role in such a path towards a sustainable facility design. In The Sustainability Advantage, the author notes that empowering every manager and employee to contribute to sustainability requires education in design for the environment, and the company's business, environmental and social record of accomplishment[15]. Once empowered, the employees can guide the facility manufacturing strategy. Furthermore, the *Center for Integrated Manufacturing Studies* at Rochester Institute of Technology defines an appropriate agenda that infuses sustainability with production methods. Sustainable manufacturing, a subset of the broad topic of sustainability, is focused on the 3P's (profit, people, planet) in the context of making a product from raw materials in a manufacturing facility[16]. Thus, an overarching goal of a facility redesign should be to facilitate concern for profitability, people, and the planet while considering the production layout. The practice of sustainable manufacturing goes beyond new approaches to waste material and pollution prevention—it creates a fusion of business opportunity and social responsibility[17]. While traditional goals related to cost reduction, guide much of the process improvement, modern facility designs clearly have opportunity to look beyond these metrics through sustainability.

Concepts from lean manufacturing have appeared to guide facility redesigns towards sustainability. In addition, much of lean implementation has shown that waste reduction will be a large component of insuring a sustainable proposal. By waste, the company should consider time and money as well as materials. To begin, documenting the current state of a manufacturing process involves diagramming the methods and material usage rates for all processes related to the products[18]. This includes receipt and in-bound quality assurance of raw materials to packaging, storage, and shipment of finished goods[19]. The benchmarks here establish a vision of the goal to reduce waste.

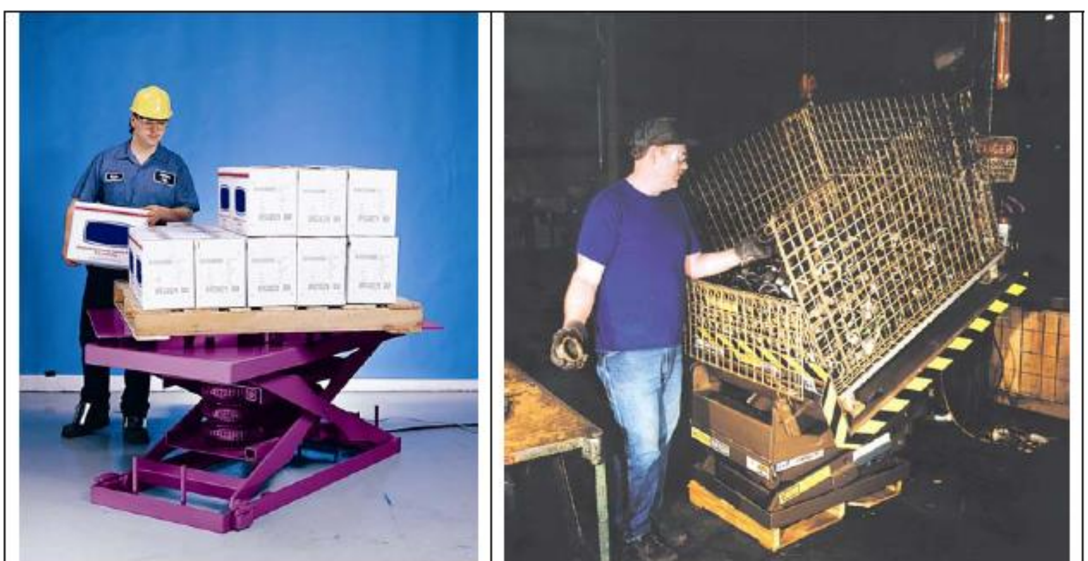
Lean Production Benefits	Environmental Improvement
Less scrap, fewer defects, less spoilage	Reduced environmental waste
Fewer defects, less over-production, simpler products, right-sized equipment	Reduced use of raw materials
Less storage, inventory space needed	Reduced materials, land and energy consumed
Less overproduction, lighting/heating/cooling unneeded space, oversized equipment	Reduced energy use
Less over-processing, more efficient transport and work-in-process movement	Lower emissions

Lean Benefits for the Environment[20]

Beyond the products, there are many factors to consider when lean, flexible, green, and global facilities are becoming more transparent and automated.[21] Metrics have become a key component of the lean decisions. In the book Work Systems, the author notes that work measurement provides metrics that enable the value-adding activities to be managed more efficiently[22]. Clearly, the time measured in production activities is important in work systems because of its economic significance, where it is critical to know much time should be required to accomplish a given amount of work[23]. Considering time again, the material route is the lifeblood of a lean facility, setting the pace for the facility, taking orders to the floor, and delivering material on a just-in-time basis[24]. It should be noted that time studies, for example, cost money but can provide opportunities for vast resource cost reduction and savings. A material flow study is just one of the many tools a facility can use to facilitate waste reduction, creating a foundation for sustainability. Furthermore, a guiding principle behind a sustainable production method would be a 5S implementation. To truly standardize work, the fifth component of 5S, “sustain”, makes sure the benefits of 5S work by making a habit of properly maintaining the correct procedures, thus sustain is a continuous improvement technique[25]. It should be noted that sustainability is not a direct synonym here, but a company should value the concept of sustaining sustainable practices.

Ergonomics

The need for ergonomics arises out of a need for productivity, a need shared with every other component of facility design. However, worker safety and productivity should go hand in hand. In a typical assembly line, there are many areas of possible long-term injury to evaluate, such as back and eyestrain, seating positions, and reaching/lifting. One should note that approximately 30% of the American workforce is routinely engaged in jobs that expose the worker to the physical hazards associated with manual materials handling[26]. No matter how much automation a proposal recommends through a work and time study, the goal in process implementation should be fitting the job to the user. At the minimum in a facility redesign, the proposal can apply the latest OSHA standards and combine this with human factors data to insure a safe environment for the workers. The Materials Handling Institute of America (MHIA) further believes that concepts from the field of industrial engineering have had considerable influence within the field of ergonomics, particularly with regard to working smarter, not harder, and maintaining a systems view, including the economic impacts[27]. Ergonomics goes beyond making the worker comfortable for the sake of making him or her comfortable. However, proper ergonomics has been shown to decrease fatigue, a symptom that is often a precursor to injury[28]. Furthermore, the MHIA feels that ergonomics also plays a significant role in achieving the goals of lean thinking by reducing costs and improving productivity through eliminating waste (e.g., unnecessary motions) and reducing mistakes (improving quality)[29].



(a) Lift table with turn feature. (b) Lift table with tilt feature.

Lift tables with turn (a) and tilt (b) features bring the parts into the power zone[30]

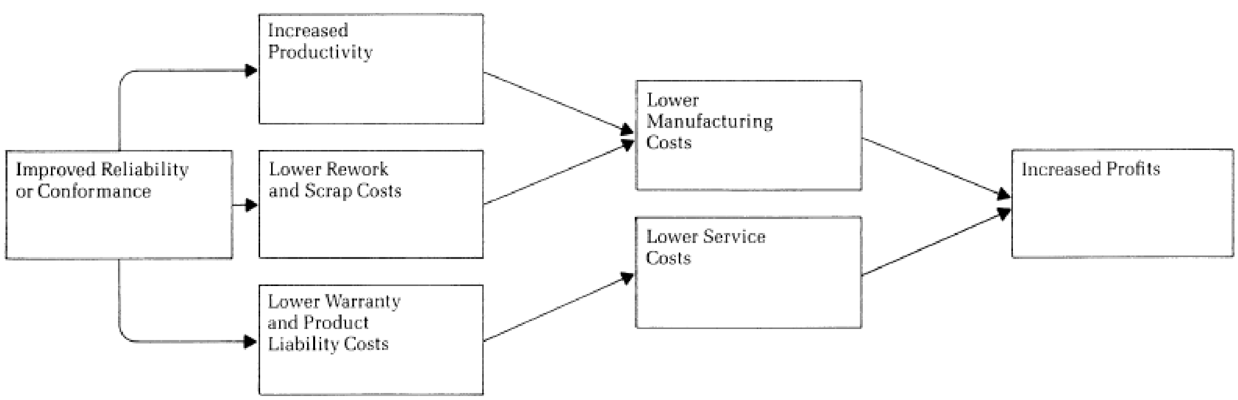
Of course, worker involvement, assuming the workers are satisfied and willing, will be critical in performing a facility design to maintain a source of profitability for the company while being environmentally and socially conscious. Any ergonomic improvements at the facility should minimize energy usage through recycled and/or sustainable building materials, solar panels, more natural lighting, and electric (as opposed to propane) forklifts.

The ergonomist Hal Kendrick points out that the easiest way for ergonomists to establish their credibility with management is to identify those obvious deficiencies where relatively inexpensive ergonomic improvements can have a quick cost–benefit payoff[31]. Such corrections can result in a significant reduction in musculoskeletal problems within a year[32]. Proposals should be avoided where the ergonomic practice is technology-centered design and humans are effectively considered as impersonal components. This leads to a “left over” approach to function and task allocation: Equipment and software first are selected, and whatever tasks were left over are assigned to humans[33]. The result usually is jobs that failed to take advantage of human capabilities, stressed human limitations, and lacked intrinsic motivation. In contrast, with a human-centered approach, functions and tasks that best can be done by humans are first assigned to them; then, whatever is left over is assigned to machines and software[34]. The reoccurrence of worker involvement and empowerment in sustainability studies and ergonomics studies provides a strong case for such implementation.

Quality

Directly applicable to a manufacturing facility, quality improvement is the reduction of variability in processes and products[35]. Excessive variability in process performance often results in waste. However, it is well known that no one single definition of quality exists. Quality costs are often defined as any expenditure on manufacturing or service in excess of that which would have been incurred if the product had been built exactly right the first time[36]. Total quality costs typically include expenditures in prevention, appraisal, internal failures, and external failures[37]. Rework may be minimal at a facility but the real issue is proper disposal of bad product, hence the need to reduce defective units in the first place. Of course, key to quality control revolves around proper metrics, which need to be well defined.

The PDCA cycle (plan, do, check, act) is a concept for creating improvement and development. The Japanese experiences in this field show that a key factor for motivation, learning and improving results is that each employee participates through the whole PDCA cycle[38]. According to the new paradigm, quality should not be achieved through inspection. Instead, the causes of bad quality should be removed, by doing things right from the beginning. Preventing mistakes instead of catching them clearly leads to more sustainable thinking. With this approach, quality improvements will lead to better productivity and lower costs[39]. The company is regarded as a chain of internal customers who pass on their good quality work result to the next internal customer[40]. The following diagram represents an effective internal supply chain for quality at a manufacturing organization.



Model of Quality Chain within Company[41]

Economics

There are three general classes of economic benefits: those associated with personnel, those associated with materials and equipment and, for product design, those associated with increased sales[42]. In addition, less tangible benefits arise that can have an economic impact. These various benefits not only can be immediate, but also in terms of life cycle cost savings[43]. The ergonomist Hal Kendrick feels ergonomics become good economics, where changes to the design of assembly workstations can result in a 15% increase in productivity[44]. In addition to economic benefits related to increased employee productivity and reduced personnel expenses, ergonomics improvements also frequently result in materials and equipment savings[45]. These include savings from reduced (1) scrap, (2) equipment, (3) production parts and materials, (4) stocking and storage of parts, (5) maintenance tools and materials, and (6) equipment damage[46]. Looking into long-term economics, Congress passed the Energy Improvement and Extension Act of 2008, ensuring the continued support solar roofing industry through 2016[47]. Solar-powered roofs currently qualify for a 30-percent federal tax credit (directly reducing the property owner's federal tax bill) as well as a five-year accelerated depreciation. Energy savings add to balanced triple bottom line. In summary, a well-designed layout for manufacturing satisfies the following objectives in layout planning: efficient movement of people and materials, effective utilization of space, safety and satisfaction of workers, flexibility to meet future requirements, and advancement of the company operational mission[48].

Design

In this chapter, all requirements, specifications, initial conditions, and the design proposals are discussed. The biggest component and principle of the facility design will be organization. This leads to a goal of eliminating waste, which will in turn promote sustainable manufacturing practices. Primary activities including streamlining material travel and reducing the impact of manufacturing processes on the environment. Support activities include lean and ergonomic improvements in the facility. Organization will guide eliminating waste through lean principles, streamlining processes to use less energy for the environment, and increasing flow to minimize non-value added costs. The lean ideas of 5-S will be the guiding principles for design decisions.

Figure 1: 5S Overview

Performing a 5S evaluation of sorting, setting, shining, standardizing, and sustaining will help to create new benchmarks for improved processes. Sorting means distinguish between the necessary and the unnecessary, and getting rid of what one does not need. Setting means establishing a neat layout so one can always get just as much of what one needs when they need it. Shining means eliminating trash, filth, and foreign matter for a cleaner workplace. Standardizing means keeping things organized, neat, and clean in the long run. Sustaining means doing the right thing continually, as promoted by all levels of employees. Specific goals of sorting from the Director of Sustainability include trash reduction, reduce energy usage, and creating employee-centered changes to the facility. It is important to consider also that management does not want weekday plant shutdowns nor interference with planned deliveries. Processes described here consider labor reduction or reallocation, employee feedback, plant layout, as well as the company waste management program. The figure below represents the entire current layout of the manufacturing facility. Please refer to the appendix to see detailed views of specific areas in the facility, especially Figures 29 and 30.

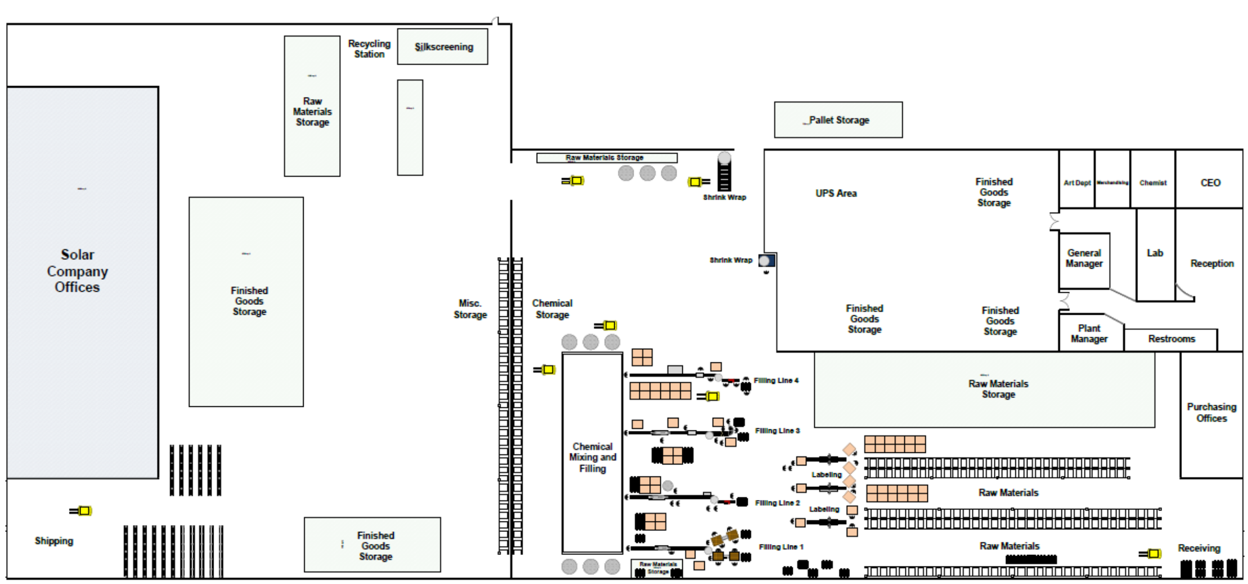


Figure 2: Initial Facility Layout

Receiving and Pallet Use Issues

Overall layout of the facility affects every employee and every customer order. Sorting and setting apply here primarily to remove raw materials not used, remove redundant inventory locations, bringing in necessary materials and equipment, and keeping aisles clear for travel. As a starting point, nearly every customer requires product shipped on pallets, but there is not one defined location for storage of pallets in the existing facility. The proposal allocates space for pallets in a location accessible to production, outside forklift travel lanes, and away from receiving as not to impede flow. Figure 4 demonstrates current pallet storage location outside the production area. Many products also require a tray/insert, but this is often stored wherever there is space, at the expense of accessibility for production. Figure 3 represents the problem of limited raw materials staging at Receiving. By keeping all raw materials closer to production, space can exist at receiving to safely receive goods, aisles are kept clear, and redundant forklift travel is minimized. Organization through sorting reduces the forklift trips done to move material out of the way. It is important to note that sorting must be done visually and language barrier considered because employees speak both Spanish and English. Further problems are documented in Figures 30 and 35 in the Appendix.

Figure 3: Raw Material Storage

Figure 4: Pallet Storage

Comparing the initial and proposed receiving areas, one can see the substantial storage in the aisles, represented in Figures 5 and 6 for a typical day at the factory. Pallets seen in Figure 4 are represented in the drawing below as well. Standardization of storage helps to remove the many different locations where finished goods, pallets, and raw materials are stored. Sufficient space exists throughout the building to accommodate all observed inventory requirements according to the plant manager. The need to get rid of clutter can also be seen in Figures 27 and 33 in the appendix. Examples are given below of current practices and a proposed solution.

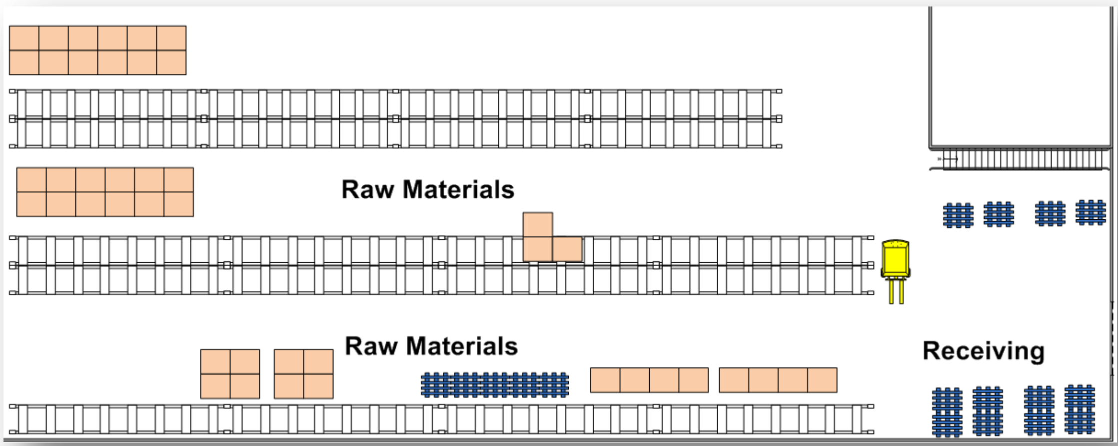


Figure 5: Initial Receiving Area

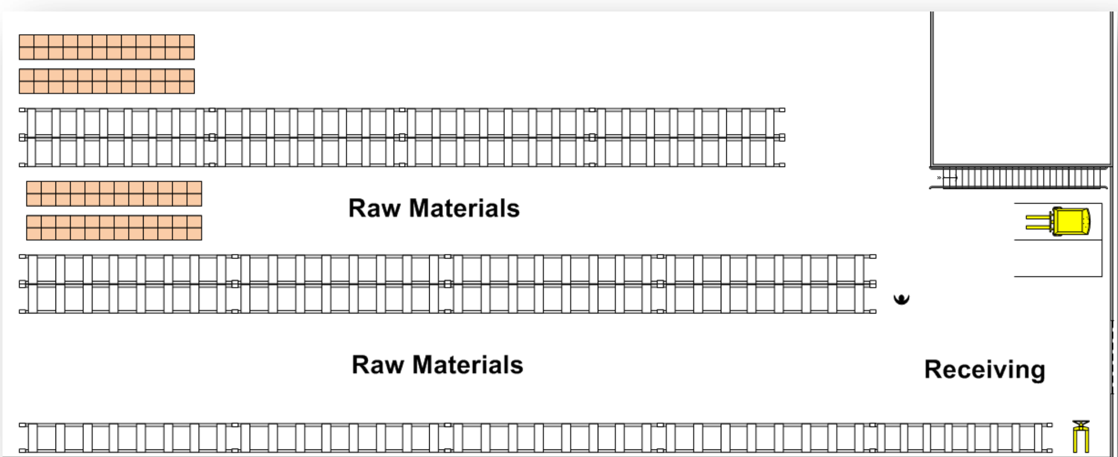


Figure 6: Proposed Receiving area

Forklift Issues

Within, the facility, the company must standardize forklift travel routes. First, one single forklift parking area can improve accessibility, workplace safety, and quicken material travel. Current practices allow forklifts to be parked anywhere, exemplified in Figure 7. Thus, by limiting the amount of times product is touched, energy can be saved, and such actions can guide sustainability through productivity improvement. Each production line also will have defined lanes for forklifts to deliver bottles, caps, packaging, and pick up finished goods. Elaboration about the design of the production steps is discussed later and in the Appendix

Figure 7: Typical Forklift Storage

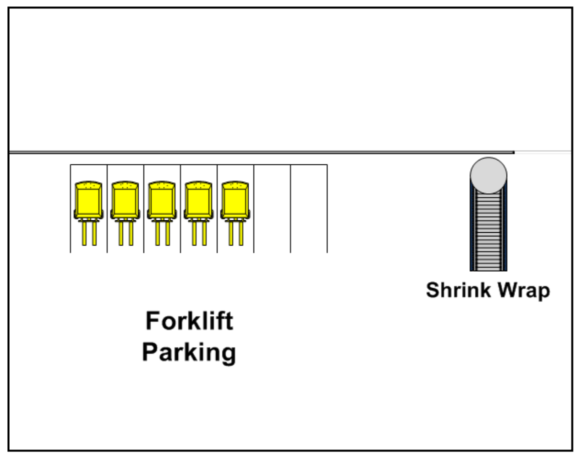


Figure 8: Proposed Forklift Storage

Floor Layout Issues

Finished goods often sit in a temporary location, so this proposal recommends pushing finished goods into the second building as soon as they are shrink-wrapped. The proposed space idea allocates defined floor locations for certain finished goods needed to always be in stock by customers and management. Refer to the appendix to see that final layout. Among the production processes, the labeling center functions efficiently, but the filling lines are more unorganized in the current state. Employees first need to understand that material should be pulled only as needed. Utilizing kanban squares through the production process will create a visual pull system, while treating every step of manufacturing as an internal customer. Excess work in process (WIP) creates travel hazards and hides the true flow of material, so the kanban squares will act as a "two bin system". The next section will contain a pictorial representation of the filling lines.

Figure 9: Labeling Center

Figure 10: Filling Line 3

While most of the workers right now are cross-trained and flexible, they have poorly defined tasks on the production line. By standardizing each component of the production process properly, labor can be reduced and can be added without increasing manufacturing time. Ergonomics will also improve by giving proper space for the workers to complete their operations through setting and anti-fatigue mats. Opportunities for shining keep the most important area of the facility, production, free of waste or contaminants. All products at the company follow the same general manufacturing steps: raw materials received, labels applied to bottles, chemicals mixed in mass quantity, bottles filled with product on assembly line, bottle capped, bottle palletized, pallets shrink-wrapped, and pallets stored for shipment to customers. Thus, each step can be accomplished with a defined recommended number of workers, leading to the principle to standardization.

Production Processes

This sections elaborates on detailed processes primarily to justify proposed staffing requirements. Labeling requires two people for one machine: one to open raw material and feed the machine, and one to direct the labeled bottles into empty boxes. Current practices allow two people to load material, but this process does not utilize the workers well. The worker on the end must have authority to stop the line if he notices a misplaced label. The same boxes that the bottles arrive in are used to move the bottles to filling after receiving labels, so this process reduces waste. Figures 28 and 29 in the appendix contain more views of this area.

Figure 11: Current Labeling Practices

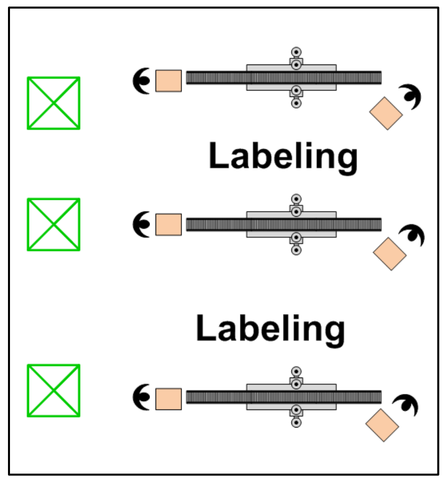


Figure 12: Proposed Labeling Area

While the empty bottles undergo labeling, mixing the actual product requires three people to supervise the proper mixing quantity, as is the current practice. Using chemicals in large quantities on pallets and a dedicated forklift, along with careful measuring, makes this a time-intensive process. These raw chemicals are kept in the rack behind the mezzanine for two reasons; first, to reduce material handling time for the mixing, and second, to keep others workers safe from any possible contaminants, although raw materials are not considered are severe safety hazard. As mentioned earlier, Shining is needed to promote cleanliness and pride in a clean work environment.

Figure 13: Chemical Storage

Filling currently requires thirteen people in Line 4, eight people in Line 3, eight people on Line 2, and eight people on Line 2: workers to load labeled bottles, insure filling happens correctly, test automatic capper, load filled bottles into trays/inserts, and load final product onto a pallet. The filling speed is the bottleneck for all of the manufacturing, so filling accuracy, spilling, and leaking are monitored carefully with this many workers. Figure 14 shows a proposed line layout with kanban squares mentioned earlier and a reduced number of workers. Many workers are idle, providing a cause for a proposed labor reduction.

Figure 14: Line Setup

Figure 15: Bottling

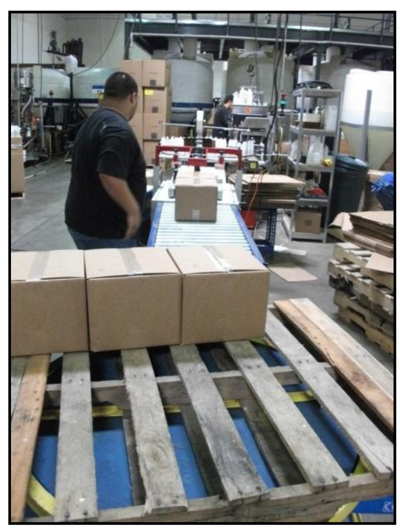


Figure 16: Loading

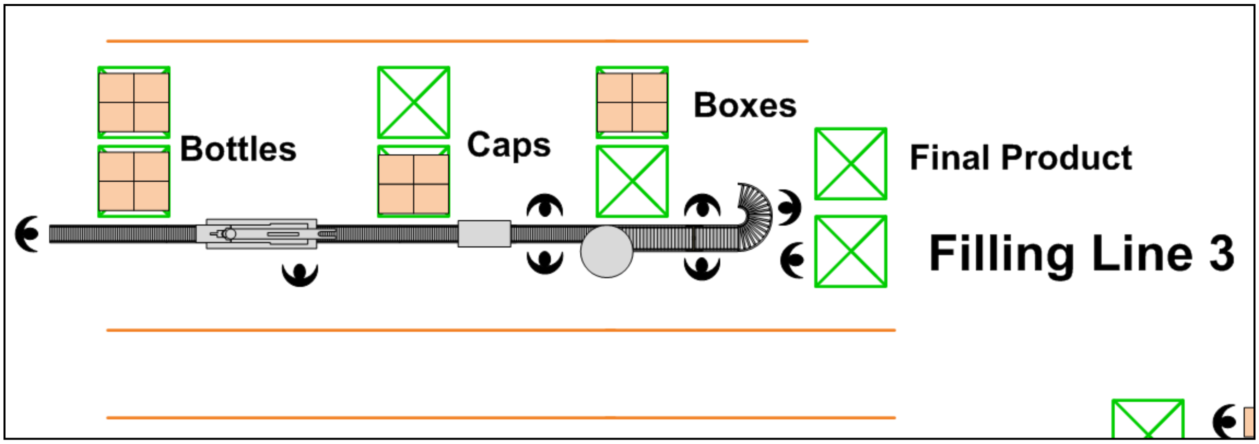


Figure 17: Proposed Line Layout

The two semi-automatic shrink-wrap machines need one person total to start and stop the wrapping. Excess capacity exists here also because when both machines were busy, a queue was never formed in my observations and according to employees. The four dedicated forklift operators are moving materials as necessary between the marked squares on the floor in order to facilitate the two-bin system. When workers bring finished goods to the shipping area, there is already a designed team to verify proper loading, shipment quantity, and time, so this system should stay in place. Generally, where there is excess capacity in the line, too many workers have been assigned to the task.

Figure 18: Semi-Automatic Shrink Wrapper

Figure 19: Automatic Shrink Wrapper

Recycling Progam

The most important component of sustainability efforts to the company at the expanded facility is the recycling and waste management program. Related to every component of 5S, the company values waste management to promote environmentally-friendly practices in addition to selling their “green” products. Ambitious goals include the desire to recycle, reduce, and reuse cardboard, label rolls, plastic, electronics, Styrofoam, shrink-wrap, and bottles. A location is already designated for this program seen in Figure 20, but again organization remains the crucial component. The following shows a representative system to aid recycling at the facility.

Figure 20: Old Recycling Center

Current practices make it difficult to promote shining and cleanliness, since nearly all production waste is considered trash. The area currently utilized has poor visibility and inadequate storage. Company goals beyond recycling include reducing, reusing, and rethinking. Management also wants customers to view recycling program as tool to encourage sustainability beyond the walls of manufacturing. The existing baler is pictures in Figure 32 in the Appendix.

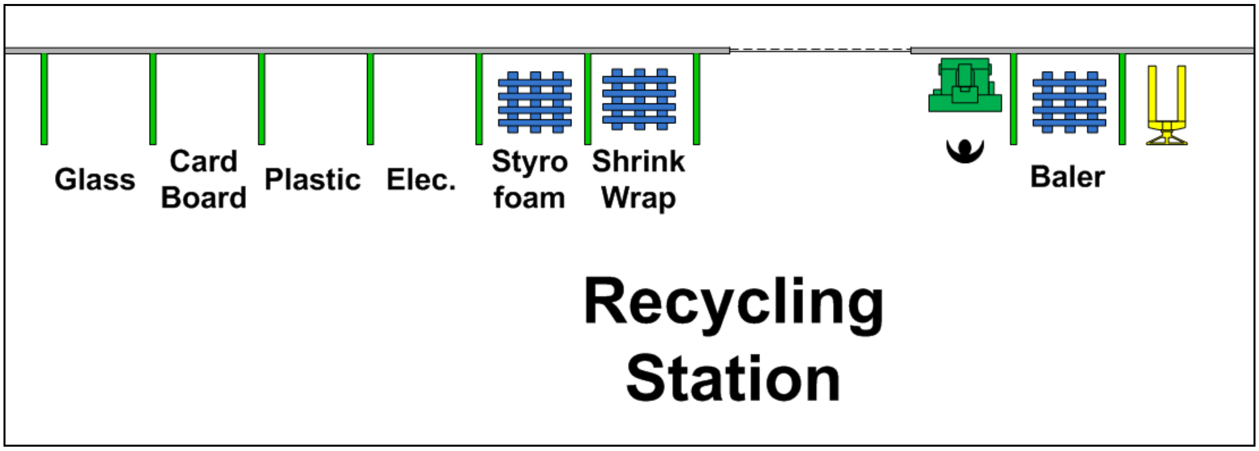


Figure 21: Recycling Center Idea

Each type of recyclable material will get its own pallet location. The new area requires minimal construction, and such costs are included in the economic justification. Economics of reducing trash output will also be discussed in Results and justification for implementing a new program will be addressed. The idea of having a central recycling center continues the efforts of the company to standardize their waste management practices. There are many recycle bins in the offices already such as this one picture below in Figure 22.

Figure 22: Comprehensive Trash Bin

Kaizen Boards & Sustaining

Sustaining is needed in all areas of improvement to insure that all the effort to reduce energy output and increase efficiency would be lost without a basis for continuous improvement. Clear signage and employee education can best help sustain green and more efficient practices, so more management and production interaction is encouraged. The company recently created a Director of Sustainability, but very few of the production workers were aware of this. By improving communication through weekly meetings, the ideas of waste removal, sustainability, and efficiency can be shared and critiqued collaboratively.

In order to foster standardizing and sustaining of sustainable choices, employees must be at the center of forward progress in the business. The philosophy of Kaizen, or continuous improvement, serves to build relationships while addressing problems. The first kaizen board deals with problems, where they are, when they happen, and who wants to take charge. While management will supervise final decisions, it is important to give the employees ownership so that they can see directly the results of their decisions and feel empowered.

Problem	Location	Date	Team

Figure 23: 5S Board

Many of the workers speak Spanish while much of management does not. The employees able to translate definitely have the opportunity to take charge in helping to address team problems. The second kaizen board serves to promote “green” ideas from employees than can be shared with other employees, management, and even customers. The company wants to be example of sustainability and “green” ideas beyond its own four walls. Figure 24 provides this opportunity.

Employee	Idea	Date

Figure 24: 5S Board

Often at the end of a shift or workday, workers leave material and equipment exactly in its last operation, without cleaning up. It should not become another person’s job to clean up or organize. A daily cleaning checklist should allow equipment to return to its proper place, and provide a facility worth showing to customers at any time of the day, such as offered below (in Spanish and English). The implementation of shining should be such that it supports the company mission: “Encourage among our families and employees important habits”. Standardizing is needed to encourage best practices for manufacturing and for the environment through the use of visual controls and employee empowerment. Efforts from setting, sorting, and shining would be lost without standardization. An effective location for the 5S boards exists near the semi-automatic shrink-wrapping station, because many employees pass by this area.

Whether daily or weekly, the desire to maintain a clean workplace will let the company bring customers in to the facility. The board is detailed below. Please refer to Figure 28 in the appendix to see placement of the 5S boards.

Chore	Completed
Walk floor from Shipping back to Receiving	
Remove materials from machines and equipment	
Record WIP and output from day's work	
Sweep around production floor and filling lines	
Ensure travel lanes are clear	
Park forklifts in designated locations	
Put trash and recycling in appropriate areas	

Figure 25: 5S Board

Methodology

As initially described in the Design chapter, the 5-S implementation looks at waste reduction and/or removal, so areas of the facility will be compared and judged accordingly. Each of the four areas mentioned in design will have been affected by at least one component of 5S, especially the areas of standardization and sorting. Many site visits at the facility provided opportunities to observe the manufacturing lines, document material flow, and speak with employees. CAD drawings in Microsoft Visio and blueprints will show "before" and "after" floorplans to demonstrate placement of proposals and ideas. Looking ahead to qualitative results, modifications and recommendations in the facility will adhere to the sustainability policies set forth by the company in order to continue their mission as an environmentally friendly company. Methods for continuous improvement will allow opportunities for employees to be accountable with each other, management, and the environment. In addition to meeting environmental goals created by the company, the proposal will be justified economically using NPV and Payback Period. All steps in the production process need signs and directional indicators to promote the 5S processes. Areas of the floor and wall must have tape or paint to demonstrate best practices and encourage standardization of everything implemented. Time studies had little value because of erratic times and inconsistent production schedules, however they provided a good representation for the general pace of material flow. Several example process flow charts helped to defined the unorganized storage areas and show areas of improvement. The economic analysis covers necessary labor, materials, and equipment for the new design to be implemented.

Results

Defining tasks on the production line allowed for insight into productivity. Because workers were often idle, allowable reductions were expected in each line. It is reiterated throughout this report, but the project can be justified economically without labor reductions should the management decide increased business requires more help. The following table summarizes the reduction in labor through defined productivity on the filling lines

	Initial Workers	Proposed Workers	Reduction
Filling Line 1	13	12	1
Filling Line 2	8	7	1
Filling Line 3	8	8	0
Filling Line 4	9	6	3
		TOTAL	5

Table 1: Labor Reduction

Because much of the facility redesign focused on organization through 5-S, the scattered number of raw material and finished goods locations has been reduced, although ideally there would be one location for each. These changes in placement have promoted flow in the facility.

	Initial Number	Proposed Number	Reduction
Raw Material Locations	7	5	2
Finished Goods Location	6	3	3

Table 2: Inventory Locations

Using data from site visits, pictures, and some estimates, WIP of raw materials has been reduced greatly. These numbers are for initial approximations and only serve as a guide for true WIP reduction based on typical days observed at the facility.

	Initial Pallets	Proposed Pallets	Reduction
Expected Raw Material WIP	65	41	24

Table 3: Estimated WIP Reductions

Previous efforts to recycle were limited primarily to office waste. Efforts at recycling, reducing, and reusing were poorly organized and initiated only by management. The new program allows everyone to visually see what materials can be recycled versus being thrown away. Nearly all employees in the production area will pass by this area. Recycled materials can often be sold to third parties, but his was not factored into the economics because little data exists to justify this. As the company seeks to buy from more sustainable suppliers, this recycling program will further help efforts in reducing, reusing, and rethinking. Figures 29 and 30 in the appendix provide a "before and after" comparison. The following section details the results of the manufacturing area. See Figure 28 in the appendix for placement of the 5S boards.

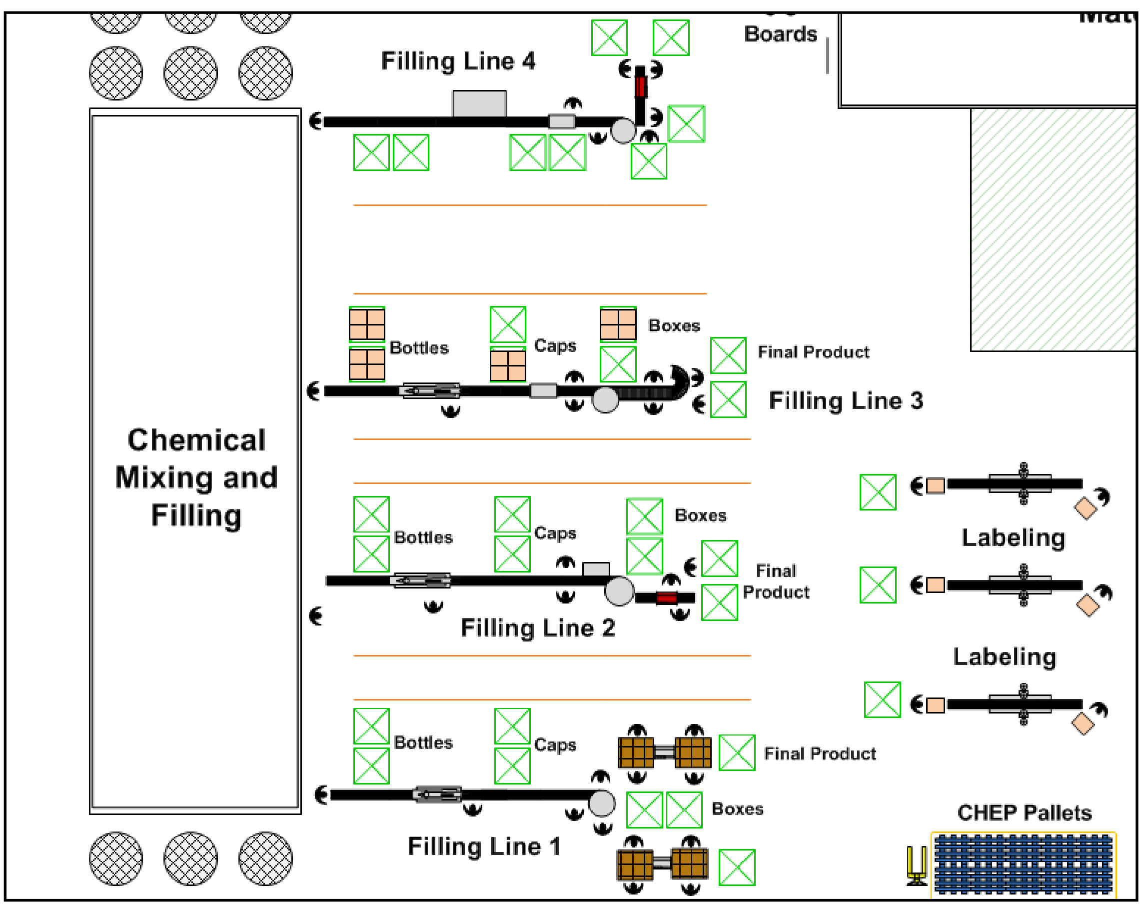


Figure 26: Final Manufacturing Layout

Economic Analysis

Primary economic justification was based on two components: labor savings from defined tasks on the production lines and implementing the recycling/waste management program. Because business has shown potential to grow, a second justification without labor savings is included.

The Plant Manager and General Manager have reiterated that the company cannot afford to halt production during the workweek. Thus, overtime shifts on Saturday are recommended to move equipment, move materials, place floor markings, and implement 5-S projects. These shifts would require ten employees. Because of the changes, an additional Saturday of training would benefit the workers. In addition, the implementation cost considers the construction and management of the recycling area. Management has stated that some employees are capable of any construction, so all labor is billed at $15.00/hour x 1.5 overtime = $22.50/hour.

Materials cost includes 5-S signs, marking tape and paint, anti-fatigue mats, and equipment needed to transform the facility. In the Appendix, Tables 5 and 6 contain detailed explanations of costs.

Total Implementation Labor Cost: $15,600

Total Implementation Materials Cost: $3180

The proposed design has eliminated the need for five workers. At the rate of $15.00 for 40 hours per week for 50 weeks per year, this translates to a yearly savings of $30,000 per employee.

Total Estimated Labor Savings: $150,000

As mentioned earlier, the recycling/waste management program solely can justify this project. Currently, the company has trash hauled away once per month at a rate of $1850 per month. The reduced trash container and recycling system costs $278 per month. In addition, much of the recycling can be sold on top of this savings, but this was not included because of extreme variations in estimates of profit.

WASTE MANAGEMENT SAVINGS			
	Rate	Months	Cost
Trash Collection	$1,850.00	12	$22,200.00
Recycling Program	$ 278.00	12	$3,336.00
		SAVINGS	$18,864.00

Table 4: Waste Management Savings

This proposal was evaluated using a discount rate of 15% over a ten-year life, based on an acceptable lifespan given by management. With an initial investment of $18,780, annual savings of 18,680.00, annual costs of $3,340.00, the project has a positive net present value and short payback period. Table 8 in the Appendix expands the ten-year investment.

NPV = $59160

Payback Period = 1 year

Conclusions

Goals of promoting sustainable waste management, minimizing types of lean waste, properly storing inventory, improving workplace communication, and defining production tasks will be addressed in this facilities redesign through 5S. Each of the four areas mentioned in design will have been affected at least one component of 5S, especially the areas of standardization and sorting. In addition, methods for continuous improvement will allow opportunities for employees to be accountable with each other, management, and the environment.

- The most important result was a demonstrated reduction in trash headed to landfills and related economic savings.
- Using 5S provided a clear way to promote organization, follow company principles, and provide standardized methods in manufacturing.
- As mentioned earlier in the proposal, times studies became difficult to gather and interpret.
- In addition, actually inventory data from the company was fragmented and somewhat proprietary, so a more in-depth quantitative solution would have been difficult.

Using this facility redesign as a starting point, the company can promote sustainable manufacturing practices best by bringing in specially trained employees and having all levels of management support any changes.

Appendix

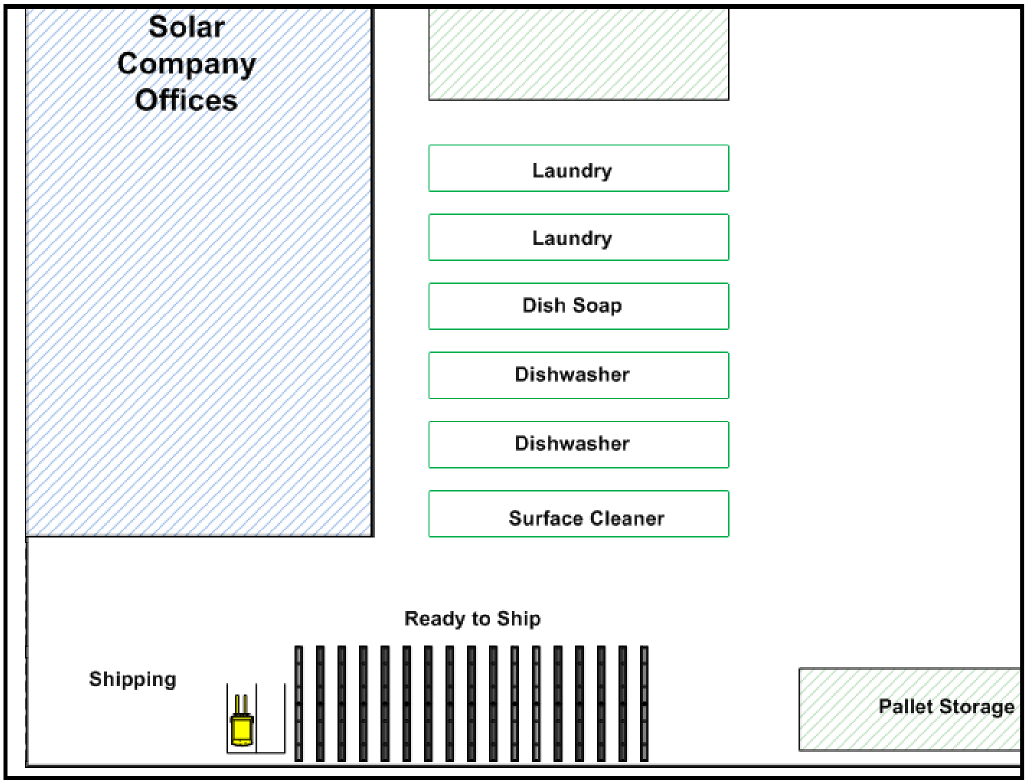


Figure 27: New Shipping Area

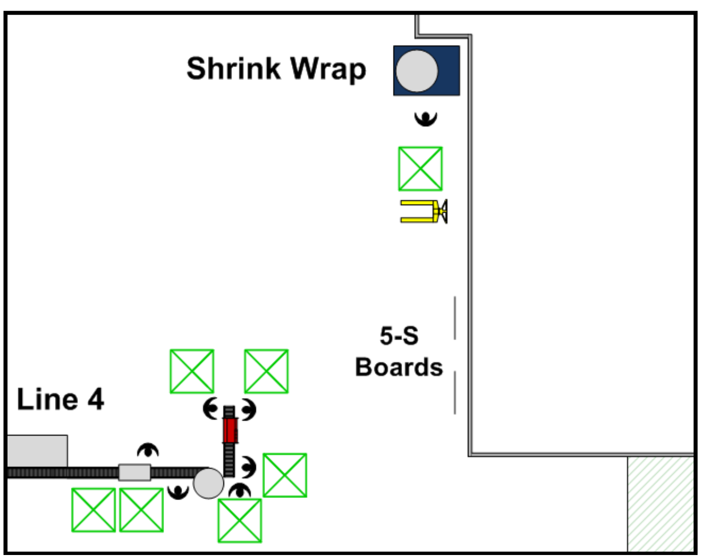


Figure 28: Shrink Wrap and 5S Boards Placement

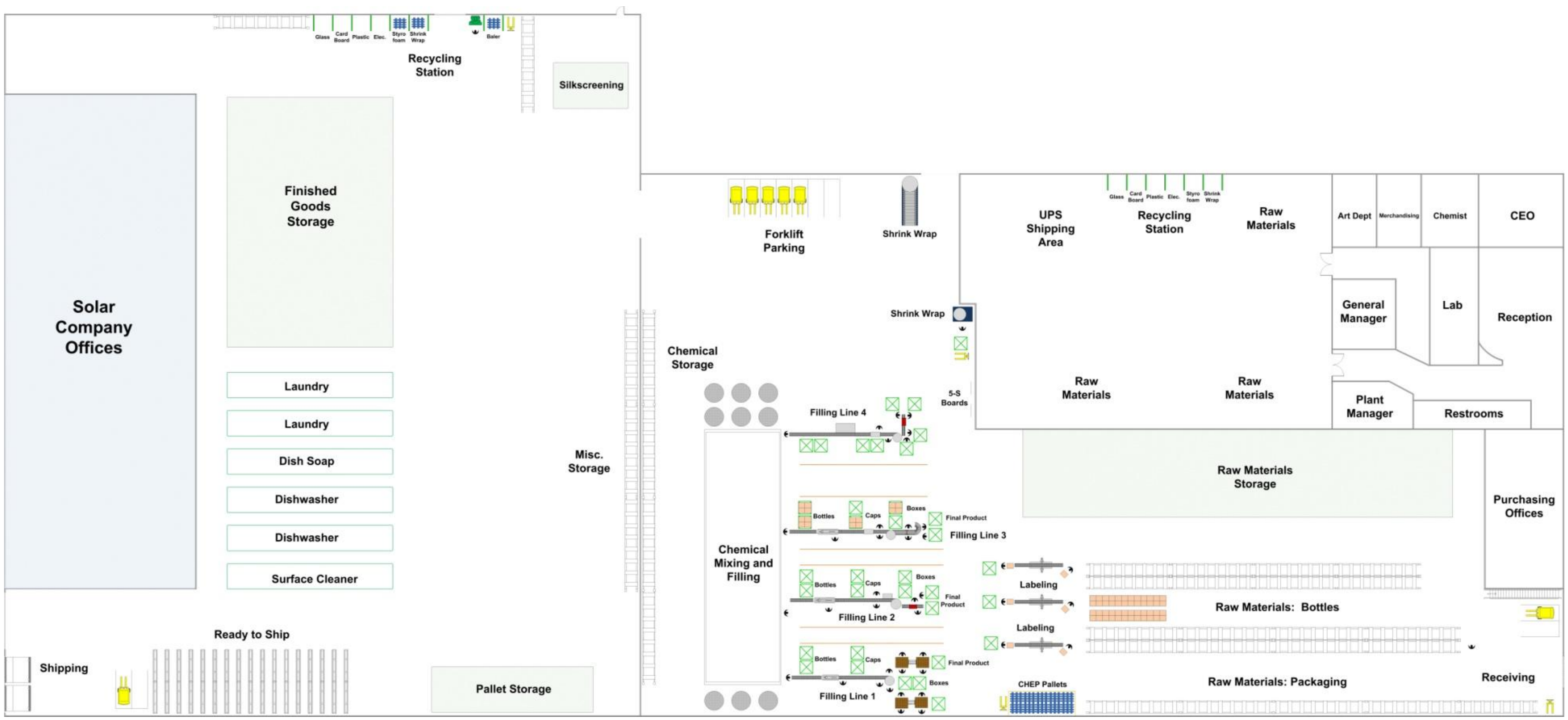


Figure 29: Final Facility Layout

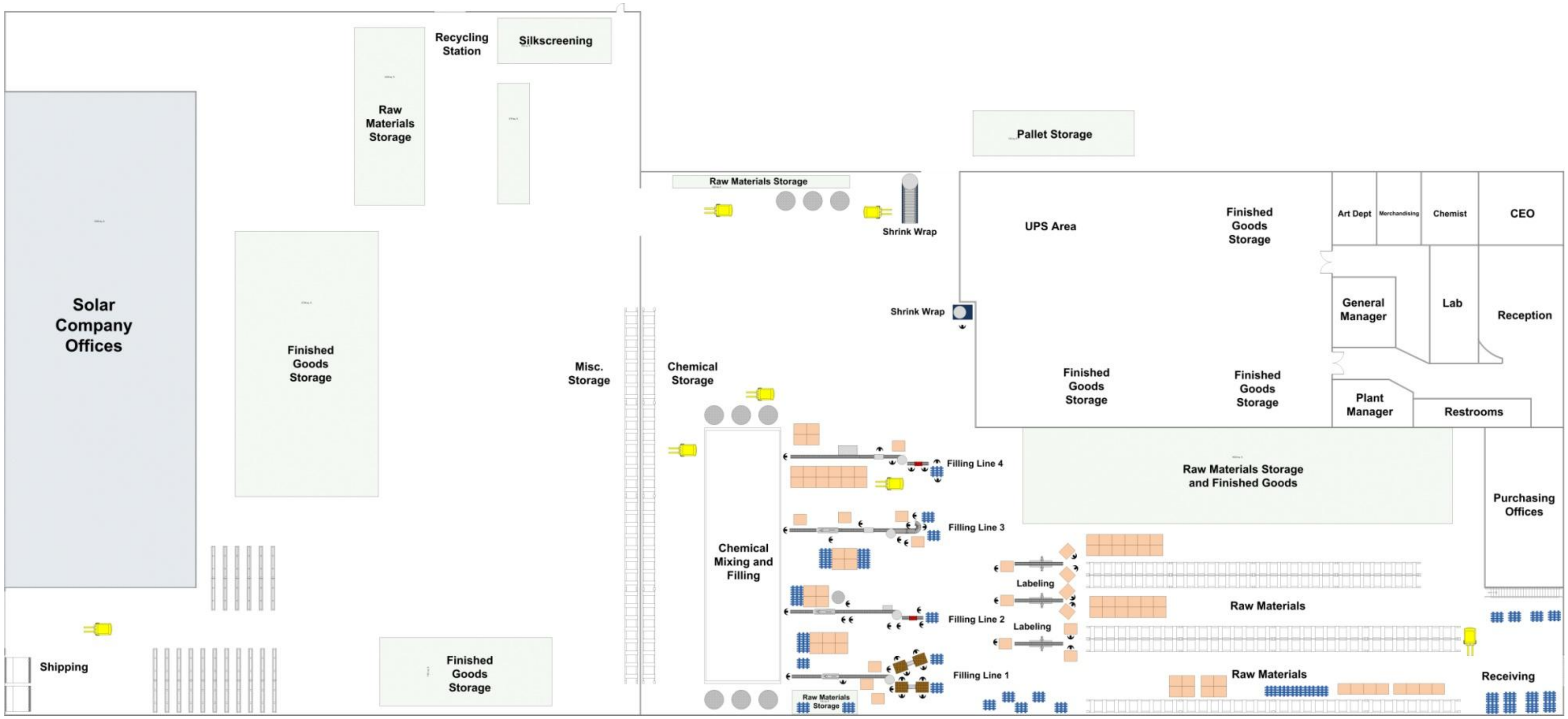


Figure 30: Initial Facility Layout

Figure 27: Receiving Area

Figure 27: Receiving Area

Figure 28: Labeling Machine

Figure 29: Unlabeled Bottles at Labeling Machine

Figure 30: Extra Semi-Finished Goods

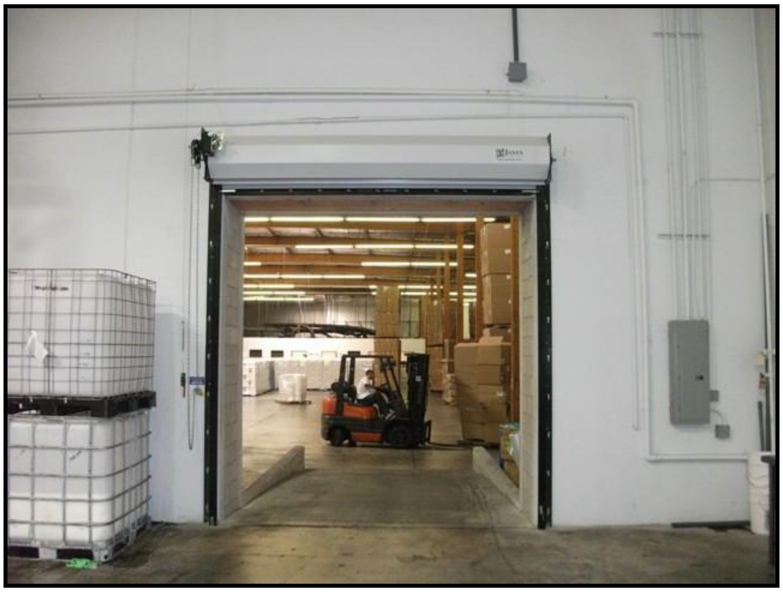


Figure 31: Door to Expanded Facility

Figure 32: Baler

Figure 33: Shipping Area

Figure 34: Silk-screening

Figure 35: Outdoor Pallet Storage

Figure 36: Semi-automated Filling Line 4

LABOR COST					
	Rate	Overtime Factor	Employees	Hours	TOTAL
Saturday Overtime Shift	$15.00	1.5	10	8	$1,800.00
Saturday Overtime Shift	$15.00	1.5	10	8	$1,800.00
Saturday Overtime Shift	$15.00	1.5	10	8	$1,800.00
Saturday Overtime Shift	$15.00	1.5	10	8	$1,800.00
Saturday Training Shift	$15.00	1.5	40	8	$7,200.00
Recycling Center Construction	$25.00	1.5	4	8	$1,200.00
				TOTAL	$15,600.00

Table 5: Labor Costs

MATERIALS COST			
	Price	Qty	TOTAL
Keep Aisles Clear Floor Sign	$28.33	3	$84.99
Marking Tape, Orange	$39.20	2	$78.40
Marking Tape, Red	$20.06	1	$20.06
Marking Tape, Green	$39.20	4	$156.80
Sign, Floor, Warning Forklift Traffic	$27.65	2	$55.30
5S Banner Signs	$199.99	1	$199.99
Anti-fatigue Mat, 2 x 3 Ft, Black	$48.60	32	$1,555.20
Scissor Lift Rental	$1,025.00	1	$1,025.00
		TOTAL	$3,175.74

Table 6: Material Costs

Material	Reference
Keep Aisles Clear Floor Sign	http://www.5ssupply.com/shop/pc/viewPrd.asp?idproduct=265&
Marking Tape, Orange	http://www.grainger.com/Grainger/items/1F166?Pid=search
Marking Tape, Red	http://www.grainger.com/Grainger/items/1F172?Pid=search
Marking Tape, Green	http://www.grainger.com/Grainger/items/1F168?Pid=search
Sign, Floor, Warning Forklift Traffic	http://www.grainger.com/Grainger/items/1VD21?Pid=search
5S Banner Signs	http://www.enna.com/productcart/pc/viewPrd.asp?idproduct=338
Anti-fatigue Mat, 2 x 3 Ft, Black	http://www.grainger.com/Grainger/items/2RPN1?Pid=search
Scissor Lift Rental	http://www.dahlsequipment.com/rentalrates/aerial.htm

Table 7: Implementation Materials References

NET PRESENT VALUE							
Year	Investment	Revenue	Costs	Annual Cash Flow	Net Cash Flow	PV Factor	PV
0	(18,775.74)				(18,775.74)	1.00	(18,775.74)
1		18,864.00	3,336.00	15,528.00	15,528.00	0.87	13,502.61
2		18,864.00	$3,336.00	15,528.00	15,528.00	0.76	11,741.40
3		18,864.00	3,336.00	15,528.00	15,528.00	0.66	10,209.91
4		18,864.00	3,336.00	15,528.00	15,528.00	0.57	8,878.18
5		18,864.00	3,336.00	15,528.00	15,528.00	0.50	7,720.16
6		18,864.00	3,336.00	15,528.00	15,528.00	0.43	6,713.18
7		18,864.00	3,336.00	15,528.00	15,528.00	0.38	5,837.55
8		18,864.00	3,336.00	15,528.00	15,528.00	0.33	5,076.13
9		18,864.00	3,336.00	15,528.00	15,528.00	0.28	4,414.03
10		18,864.00	3,336.00	15,528.00	15,528.00	0.25	3,838.28
						NPV	59,155.70

Table 8: Net Present Value

Flow Process Chart

Location:	Facility				
Activity:	Finished Goods Material Travel				
Date:	3/25/2010				
Operator:		Analyst:			
Circle Appropriate Method and Type					
Method:	Present	Proposed			
Type:	Worker	Material (circled)	Machine		
Remarks:					
	Study of Finisheds Goods material handling				

Summary

Event	Present	Proposed	Savings
Operations	3		
Transport	4		
Delay	2		
Inspection	1		
Storage	0		
Time (min)			
Distance (ft)	270		
Cost			

Event Description	Operation	Transport	Delay	Inspection	Storage	Time (min)	Dist (ft)	Notes/Method Recommendation
Finished goods put onto pallet	●					-	-	
Travel to shrink wrap		●				-	35	
Pallet shrink wrapped	●					-	-	
Worker moves pallet aside		●				-	5	Not a defined location
Pallet waiting for forklift			●			-	-	No clear signal for forklift drivers
Pallet moved to staging area		●				-	200	
Waitin for completed order			●			-	-	Why not final shipping area?
Pallet moved to shipping area		●				-	-	
Pallet inspected before loading				●		-	-	
Pallet loaded onto truck	●					-	30	
					Total =		270	

Figure 37: Finished Goods Initial Travel

Flow Process Chart

Location:	Facility		
Activity:	Initial Material Travel Study		
Date:	3/25/2010		
Operator:		Analyst:	
Circle Appropriate Method and Type			
Method:	Present	Proposed	
Type:	Worker	Material	Machine
Remarks:			
	Study of empty bottles received from supplier		

Summary			
Event	**Present**	**Proposed**	**Savings**
Operations	2		
Transport	3		
Delay	1		
Inspection	1		
Storage	1		
Time (min)			
Distance (ft)	860		
Cost			

Event Description						Time (min)	Dist (ft)	Notes/Method Recommendation
Receiving						-	10	
Move to rack storage						-	500	Stored far from POU
Placement on racks						-	-	
Moved to filling lines						-	320	
Checked at filling lines						-	-	Why check so late?
WIP Delay						-	-	
Travel to Point of Use						-	30	
Actualy Point of Use						-	-	
					Total =		860	

Figure 38: Raw Material Initial Travel

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