WAREHOUSE REDESIGN OF FACILITY LAYOUT

FOR WEGMANS FOOD MARKET

A Thesis in
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by
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ABSTRACT

This report presents the warehouse redesign of Wegmans Food Markets’ grocery warehouse located in Pottsville, PA. The Wegmans Food Markets Inc. is a U.S. regional supermarket chain. This Pottsville warehouse is used as Wegmans retail-service-center (RSC) dry grocery warehouse and it is the core part of Wegmans future five to ten years strategy plan. However, there are a few warehouse racks and cranes installed. The objective is to develop an alternative plan for the facility that can maximize the efficiency and capacity in order to fulfill the requirements for future growth.

The current warehouse layout and operations were reviewed. And some quantitative analysis methods were used to evaluate the current process and inventory status. After that, the two main areas which affect the majority of processes were identified -- the Floor Picking area and the High Velocity Picking area. Two alternative redesign methods were proposed for each of these areas. And four combinations of these alternatives have been evaluated. The final alternative plan which was determined to be the best combined the additional Rack Picking and Floor Picking area together and rearranged the High Velocity Picking area with narrow aisles and one level rack for replenishments. This alternative improved the efficiency of operations at a relevant low implementation cost and short reconstruction time.
# TABLE OF CONTENTS

LIST OF FIGURES ........................................................................................................... v
LIST OF TABLES ............................................................................................................. vi
ACKNOWLEDGEMENTS ................................................................................................. vii

Chapter 1 Introduction ................................................................................................. 1
  Problem Statement ..................................................................................................... 2

Chapter 2 Literature Review ....................................................................................... 4
  Design Perspective ..................................................................................................... 4
  Evaluation Perspective ............................................................................................... 8

Chapter 3 Analysis and Design .................................................................................. 10

Chapter 4 Results and Evaluation ............................................................................. 23

Chapter 5 Conclusion ................................................................................................... 27
  Appendix A  Current RSC Grocery Layout by Zones .................................................. 28
  Appendix B  Output Items Volume by Picking Type ..................................................... 29
  Appendix C  Arrangement in High Velocity area ......................................................... 30

References ..................................................................................................................... 31
LIST OF FIGURES

Figure 3-1 Output Items Volume by Pick Type – Total ......................................................... 16
Figure 3-2 Output Items Volume by Pick Type – Tonnage .................................................... 17
Figure 3-3 Output Items Volume – Combine High Velocity and Block Picking .................... 18
Figure 3-4 Tonnage Proportion of each Picking Type ......................................................... 19
Figure 4-1 Illustration of Current High Velocity area ......................................................... 24
LIST OF TABLES

Table 3-1 Current Section Distribution ................................................................................. 15
Table 3-2 Current Density Factor ............................................................................................. 20
Table 3-3 Density Factor after Double Inventory ................................................................. 21
Table 3-4 Section Distribution after Double Inventory ......................................................... 21
Table 3-5 Section Distribution after Double Inventory and Modification ......................... 21
Table 4-1 Alternatives after Combination ............................................................................... 25
Table 4-2 Alternative Evaluation Table .................................................................................... 26
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HUI LIU
Chapter 1

Introduction

A supply chain may be defined as an integrated process wherein a number of various business entities (i.e., suppliers, manufacturers, distributors, and retailers) work together in an effort to: (1) acquire raw materials, (2) convert these raw materials into specified final products, and (3) deliver these final products to retailers. This chain is traditionally characterized by a forward flow of materials and a backward flow of information and capital (Benita M. Beamon, 1998). And now, it has new definition: a supply chain is an extended enterprise that crosses the boundaries of individual firms to span the related activities of all the companies involved in the total supply chain (Coyle, Langley, Novack, and Gibson, 2012). Although every effort is being focused on lean manufacturing to reduce warehousing and inventory right now, warehousing will still play a critical role in the supply chain to fulfill accuracy and cycle time performance and customer service.

Generally speaking, a warehouse is a hub in a supply chain network where goods are temporarily stored or value added and then routed to the next destination. In world-class warehousing, a warehouse should hold inventory used to balance and buffer the variation between production schedules and demand; accumulate and consolidate products from various points of manufacture within a single firm, or from several firms, for combined shipments to common customers; provide same-day delivery to key customers and rapid response to customer demands and serve as the facility where key product customization activities are executed including packaging, labeling, marking, and pricing. (Frazelle, 2002, p.20-21).

This research was conducted for Wegmans Food Markets’ grocery warehouse located in Pottsville, PA. The Wegmans Food Markets Inc. is a U.S. regional supermarket chain. It has more
than 75 stores spread across the eastern U.S. Wegmans has appeared on Fortune’s annual “Ten Best Companies to Work For” list since its inception in 1988, and has ranked among the top ten for eight consecutive years. It is one of the top large grocery chains in the United State. Wegmans is famous of its diversification and freshness. As a leading grocery supermarket, Wegmans’ success is based on the fulfillment of customer service and the high quality of their products. All of these are related with the supply chain managements and warehouse operations.

This Pottsville warehouse is used as Wegmans retail service center dry grocery warehouse. It is a medium size warehouse with 310400 square foot and 66 docks in one side. It supplies eastern with food, pet use, and detergents etc. This warehouse is the core part of Wegmans five to ten year strategy plan. Wegmans wants to balance the main warehouse in Rochester and this in order to better fit future development and serve eastern people.

Problem Statement

As said above, this Pottsville grocery warehouse was built five years ago and planned for future growth. At that time, there was a little warehouse racks and a few cranes installed. But now, Wegmans is at the point where they are ready to move on and increase the current volume. In the future plan, the Pottsville facility will be a critical component to achieve Wegmans growth and development. So, the primary goal is trying to maximize the efficiency and capacity of the facility in order to fulfill the requirements for the future plan.

In addition, this project also needs to satisfy several objectives and constraints in order to improve the warehouse operation:

- The current warehouse operations should not be interrupted by the redesign layout, which means that it’s better to improve the current layout with some modifications instead of redesigning the facility with a brand new layout.
- The redesign capital budget and time budget also should be considered. It is better to carry out an optimal result under the considerations of capital, time, and proposed layout.
- The proposed layout must be robust, able to meet the future Five to Ten years need and improve the flow of products and employees throughout the facility. In other words, the design also needs to improve the efficiency of the goods movement and make it easy for future modification.

The research approach for this paper will utilize the following steps: First, collect or develop scaled drawings of the existing warehouse facilities and verifying their accuracy. Second, define the goods to be stored in the warehouse and the volume anticipated during the planning horizon. Third, identify the potential areas of improvement in the existing warehouse operation. The potential for improvement may exist because the operation lacks sufficient capacity to handle future requirements or because excising facilities, methods, equipments, or labor forces are not the most efficient or effective available. Fourth, propose to identify alternative facility, equipments, procedural and personnel plans that will eliminate or minimize the deficiencies in the existing warehouse. And consider the both economic and qualitative assessment of each alternative plan of action. The rest of this paper will include the following sections: literature review, analysis, design, results, evaluation, conclusion, appendices and reference.
Chapter 2

Literature Review

There are several documents which provide insight to solve the redesign problems for warehouse. Based on B. Rouwenhorst, B. Reuter’s words, there are three different angles from which a warehouse may be viewed: the processes, resources, and the organization. Products arriving at a warehouse subsequently are taken through a number of steps called processes. Resources refer to all means, equipments and personnel needed to operate a warehouse. And the organization includes all planning and control procedures used to run the systems (B. Rouwenhorst, B. Reuter et al., 1999). In Rouwenhorst’s paper, they mentioned that the warehouse processes contain receiving process, storage process, order picking and shipping; the warehouse resources contain storage system, retrieval equipments, computer system, personnel and material handling equipment; and the warehouse organization contains the policies for receiving, storage, order picking and shipping process. They all have to be considered to contribute for the warehouse performance. However, in the following section of literature review, different perspectives literature will be presented.

Design Perspective

In a warehouse is a redesign project, it is better to start the literature review from the perspective of the current layout. From Frazelle’s book we know that the warehouse layout is the organization of the physical facilities of a company to promote the efficient use of equipment, material, people and energy. The goals of a warehouse layout are to minimize unit costs, optimize quality, promote effective use of people, equipment, space and energy, provide for employee
convenience, safety and comfort, control project costs, and achieve production deadlines. The process of laying out a warehouse is just like putting together a puzzle. All of the pieces need to be defined before complete the puzzle. Defining those pieces is the purpose of profiling, benchmarking, simplifying, computerizing, and mechanizing warehouse operations. (Frazelle, 2002, p. 265). So, in order to build a layout, those processes and systems must be put together in a synergistic and flexible floor pace.

Since the Pottsville warehouse has insufficient racks and equipment, the pallet storage systems in the warehouse need to be examined, because their size often dictates the configuration of the rest of the operation. The most popular pallet storage systems are: block stacking, stacking frames, single-deep selective pallet rack, double-deep rack, drive-in rack, drive-thru rack, and the push-back rack. (Frazelle, 2002, p. 202). However, based on the situation of the Pottsville warehouse, the single-deep pallet rack, double-deep pallet rack and the push-back rack will be on the top of these choices. These will be explained below:

A single-Deep Pallet Rack is a simple construction of metal uprights and cross-members providing immediate access to each load stored. It is cheap and allows full accessibility to all unit loads. However, the major disadvantage is the amount of space devoted to aisles, normally 50% - 60% of the available floor space. But it is popular for items whose storage requirements are less than six months. (Frazelle, 2002, p. 208).

A double-Deep Pallet Rack is just like the single-deep selective rack, the only difference is two unit load positions deep. The advantage of double-deep rack facings is that fewer aisles are needed. It can be used for more than one pallet SKU and the product is received and picked frequently in multiples of two pallets. (Frazelle, 2002, p. 208).

A push-Back Rack is the push-back rack provides last-in-first-out, deep-lane storage using a rail-guided carrier for each pallet load. As a load is removed from the front of a storage lane, the weight of the remaining load automatically advances the front load to the rack face.
Hence, every SKU has a load that is immediately accessible. So, it is appropriate for medium to fast-moving SKUs with three to ten pallets on-hand. It may be useful for Wegmans’ large fresh good which need to be rerouted in a shorter time. (Frazelle, 2002, p. 208).

A pallet retrieval system is also important for warehouse design. The most popular pallet retrieval and put away systems are: walkie stackers, counterbalance lift trucks, straddle trucks, straddle reach trucks, sideloader trucks, turret trucks, hybrid trucks, and automated storage and retrieval machines. There have the proper retrieval system is necessary to allow the pallet storage system to perform the operations. (Frazelle, 2002, p. 214)

After that, the design of order-picking policies is also a critical component. The most common objective of order-picking systems is to maximize the service level subject to resource constraints such as labor, machines, and capital (Goetschalckx and Ashayeri, 1989). Order picking involves the process of clustering and scheduling the customer orders, assigning stock on locations to order lines, releasing orders to the floor, picking the articles from storage locations and the disposal of the picked articles. (Koster, Tho Le-Duc and Kees, 2006). Picking policies involve assigning items or orders to picking tours. Common picking policies include strict-order picking, batching (Rosenwein, 1996), and zoning (Jane, 2000; Petersen, 2002). Routing policies determine the route of a picker for a picking tour, which specifies the sequence in which stock keeping units are to be picked. These policies range from simple heuristics (Hall, 1993; Petersen, 1997; Roodbergen and Dekoster, 2001) to optimal procedures (Ratliff and Rosenthal, 1983). Moreover, the discussion between the manual order-picking and machine order-picking is also an important topic.

The storage policies are also a part of order-picking policies. Storage policies assign SKUs to storage locations. The common way to handle storage included assigning SKUs randomly throughout the warehouse, to location based on picking volume, or grouping similar SKUs within certain warehouse regions. The most common policy is the closest-open location, which means
storing SKUs randomly based on the next available location. Another storage policy is the volume-based storage (VBS) policy which assigns SKUs with the most requests or most frequently picked items to the nearest location to the pick-up and drop-off station. But this policy needs data mining and other information collection which makes it harder to manage than random storage. (Petersen and Schmenner, 1990). There is another policy named class-based storage (CBS), which is similar to the VBS that ranks all SKUs based on their activities. The SKUs are partitioned into several storage classes and randomly assigned to the particular storage area based on their class level (Charles, Aase, and Heiser, 2004). It is a combination of random storage and volume-based storage policies.

Aisle configuration is also a component that needs to be considered. In a picking process, workers need to circumnavigate aisles with picking carts or forklifts and build orders by picking items or cases from the stored pallets. Normally, the workers can pick several items via a rectangular route and get back to the put away point. However, when the warehouse become large enough, it is unwise to go through the whole rectangle in order to return to pick another item in other aisles. So cross aisle divides the warehouse and make the route more flexible and beneficial. Somebody said that it maybe not beneficial when retrieving a single item, since the cross aisle move half the pallets farther from the pickup-and-deposit (P&D). For large picking list, however, the cross aisle can make the whole tour become shorter. Today’s general recommendation is that the route flow within the facility follows a ‘flying V’ or a ‘fish bone’ formation because this can be more effective (Gue, Kevin and Meller, Russell D., 2009), which can make the expected retrieval times 20 percent lower than the traditional warehouses. However, this design is only based on the unit-load warehouses with a single, centrally-located P&D, and based on an assumption of uniformly distributed activity within and among picking aisles. However, for this Wagmans’ project, case-picking and multiple P&D points should be considered.
Evaluation Perspective

The mission of a warehouse in a simplified form is to effectively receive, store and ship product to the next step in the supply chain without damaging or delaying the product. So, the goal of a warehouse redesign is to achieve this mission under new requirements. In order to develop the optimal alternatives, the evaluation processes for the rack type, classification system and rack arrangement are important. These categories are evaluated based on the following criteria (Tobiah R., 2010):

- **Space Utilization** – the total amount of product that can be stored in the warehouse, the basic requirement is to fulfill the future 5-10 years needs.
- **Ease of Access** – ease for employees to replenish goods, pick orders, and travel time and energy economy.
- **Cost of Implementation** – the total cost of implementation including equipment, installation labor and training and the cost of delay or impact on current orders.
- **Long-Term Viability** – the ability to adapt future changes in warehouse layout and customer’s needs.

From B. Rouwenhorst et al’s paper, they proposed the criteria for warehouse performance are investment and operational costs, volume and mix flexibility, throughput, storage capacity, response time, and order fulfillment quality (accuracy) (B. Rouwenhorst, B. Reuter et al., 1999). They said that there are two types of warehouse which relate with some particular criterions. The first is production warehouse, which means the function of warehouse contains producing process. It may store raw materials, work-in-process and finished products. However, this project is the second kind of warehouse which is distribution warehouse. So, based on their paper, the prominent design criterion should be maximum throughput, to reach at the minimum investment and operational costs.
In addition, some researches also proposed to apply the lean concepts in a warehouse operation evaluation and redesign process. The key of lean concepts are focused on reducing the non-value added steps in the warehouse as much as possible and improving the velocity and flow of processing (Frank C. Garcia, 2004). The lean concept can be used on space utilization, material handling, data collection, flow control and labor management etc. For instance, the value stream map, which mean a set of all specific action, both value added and non-value added, that are needed to bake a product through the information and production flows of a manufacturing operation (Shook, J. Rother, 1999), is a comprehensive way to evaluate the warehouse process.
Chapter 3

Analysis and Design

The RSC Grocery Layout which in Appendix A show that there are fifteen different functional zones in the warehouse. Their functions are presented as follow:

- No. 1 is Drivers Lounge, which provide a refreshing place for truck drivers.
- No. 2 zone is main office of the warehouse. It takes charge the documentation and administration functions of warehouse’s transactions.
- No. 3 is the Hydrogen station. It provides power for equipments.
- No. 4 is Automated Storage and Retrieved System P&D department. It develops and maintains the No. 5 Zone
- No. 5 Zone, which is the Automated Storage and Retrieval System.
- No. 6 is the Cross District.
- No. 7 is the Reduce Delivery area.
- No. 8 is the Rack Picking area with 40,250 square foot. It serves 33 eastern stores. The rack picking area is used for medium and slow moving items. Each item just has one primary to pick.
- No 9 is Floor Picking area with 88,750 square foot. It also serves 33 eastern stores. The floor picking are can store medium to high moving items. Each item may have multiple primaries.
- No. 10 is High Velocity Picking area. Although it just has 37,500 square foot, it handles the largest amount of cases in the warehouse.
- No. 11 is High Velocity and Medium Velocity Picking backup area. It is used for Block Picking right now.
- No. 12 is Seasonal Storage area. It is designed for seasonal preparations.
- No. 13 is Salvage storage area.
- No. 14 is the Maintenance area. It is used for Inner Picking process.
- The rest of warehouse is Dock area. There are total sixty six docks in the warehouse.

From the above list, it is obvious that this warehouse has diversified functions to keep its business running well. However, the No. 10 area (High Velocity Picking) shows highly workload compared with its limited square foot. Actually, there are many items in this type of selection because of space limitation. Some items even went out in Cross District and blocked picks. So, it shows a need for more picking locations, more rack to store reserves. And it is also the main purpose of this research, to improve the warehouse for future use.

To better analysis the warehouse, it is important to analyze the transaction process. The main storage and transaction area is No. 8 (Rack Picking), No. 9 (Floor Picking) and No. 10 (High Velocity Picking). The process flow descriptions of these areas are listed below:

In current process, the receiving and cross-docking process is taking place at the docks area and high velocity area. The high velocity area serves 33 Wegmans’ stores every day. Each store has two pallets assigned. Operator receives goods and assigns to each store’s pallets based on the order they heard from the headset. In addition, Block Picking also takes place in the warehouse. Block picking is one kind of cross docking type, it process items which reserves by pallet quantity in the system. It is an efficient way to move high volume items during crossing docking. The process flow of receiving and cross-docking is as follow:

**Receiving and Cross-Docking Process Flow:**

- Truck arrive at the RSC Grocery Warehouse
- Truck directed to related dock
- Operator checks bill of lading
- Unload items to dock area
- Operator checks for damage
- Bill of lading signed
- Operator request store’s order
- Warehouse staff checks store’s order and response assignments
- Operator confirm assignments
- Assign items to each store’s pallet
- Place unassigned items to proper locations (Put-away process)

The Put-away process takes place at two areas: the Rack Picking area and Floor Picking area. Rack picking needs cranes to help store and pick and floor picking categories storage based on weight, which means the over 25 lb, 15 to 25 lb, and under 15 lb three categories. Operators will pick the heaviest item at first, and make sure the lightest items are on the top. By using this method, the operator can keep the items stable during transport. The put-away process flow is as follow:

**Put-away Process Flow:**

- Operator enter purchase order
- Purchase order receive
- Submit put-away request manually
- Warehouse stuff confirms item number
- Warehouse stuff confirms item destination (Rack/Floor)
- Operator is directed to put-away area via computer screen
- Operator confirm quantity
- Operator execute put-away
- Put-away completed with computer documents placement
The next is picking process. Rack Picking and Floor Picking process have different requirements. The Rack Picking focuses on unit load, however the floor picking will utilize the rainbow effect – it will pick multiple items based on the order requirements. When operators start a floor picking process, they will start at the heaviest items area, and then sneak to other weight area. The process flows are as follow:

**Rack Picking Process Flow:**
- Warehouse stuff sends order to operator
- Operator confirm items and quantity of the order via headset
- Operator use crane or forklift to replenish items needed to fulfill current orders.
- Check whether more items need to be picked
- Locate items at dispatching area

**Floor Picking Process Flow:**
- Warehouse stuff sends order to operator
- Operator confirm items and quantity of the order via headset
- Operator manually pick item from floor storage area by category, heavy items first
- Operator confirms picking and update inventory via headset
- Check whether more items need to be picked
- Move items at dispatching area

In addition, the Inner Packing process is taking place on the mezzanine. The Inner Packing room selects two stores at a time and operates on Sundays and Thursdays. The process flow is as follow:

**Inner Packing Room Process Flow:**
- Warehouse stuff sends order to operator
- Operator confirm items and quantity of the order via headset
- Operator manually pick item from roller rack storage area
- If item is insufficient, replenish manually
- Put finished order box on conveyor and wait for transporting

The continued expansion of Wegmans’ needs of storage space has resulted in the redesign of their current warehouse to fit the future five to ten years’ plan. The warehouse is required to be able to effectively manage the daily operations, including shipping, receiving, picking and so on. In addition, the warehouse design also needs to be flexible and able to adapt to increases in product volume, variations in product category, and facilitate the transactions. The rest of this chapter will analyze the current warehouse situation in several perspectives. However, since quantitative technique is used to measure the current receiving process, the warehouse storage system and inventory status, it is necessary to draw some assumptions and limitations in order to set the right direction for this project. The main goal of this project is to maximize the storage space of warehouse and improve the efficiency and productivity, the following assumptions and limitations have been drawn: for the process part, the truck loading and unloading process will keep the same, some lifting equipments may be still using as well; for the layout part, the warehouse will not expand,. But the cubic space can vary. Just like the racks can be moved, and the aisles also can be varied. The future plan means to double the inventory, the inventory in assumption is 200% of current inventory.
Current Section Distribution Situation

Table 3-1 Current Section Distribution

<table>
<thead>
<tr>
<th>Area</th>
<th>Map Number</th>
<th>Size (Square Foot)</th>
<th>Pallets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rack Picking</td>
<td>8</td>
<td>40250</td>
<td>1723</td>
</tr>
<tr>
<td>Floor Picking</td>
<td>9</td>
<td>88750</td>
<td>1182</td>
</tr>
<tr>
<td>High velocity</td>
<td>10</td>
<td>37500</td>
<td>3433</td>
</tr>
<tr>
<td>Cross District</td>
<td>6</td>
<td>4000</td>
<td>83</td>
</tr>
<tr>
<td>Reduced Delivery</td>
<td>7</td>
<td>10000</td>
<td>1375</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>180500</td>
<td>7796</td>
</tr>
</tbody>
</table>

The inventory status as of 3/25/2012 was found as a baseline. The High Velocity inventory has beyond its capacity and occupied some space of floor picking and cross district area because there is no rack in there. And from the inventory report, the average Days of Supply of 2012 is 11.6, which means that there is about 11 days of inventory in the warehouse totally. The contents of each individual storage location were also surveyed. Loose segregation by weight is applied for rack picking and floor picking area. In rack picking area, operator put heavier items at bottom and lighter items at top in order to keep items stable during retrieving and transporting. For the floor picking, since there are all medium to high movers and seasonal items in there, the categories of items always change season by season, and they refresh very quickly. It is hard to track each kind of items and record them in different category. So Wegmans think there are no needs for ABC classification or other more sophisticated classification rules. And the same strategy that segregates by weight and randomizes storage in each section is also applied in floor picking area.
Tonnage Output Trend by Picking Type

The Appendix B shows the Output Items Volume by Picking Type. It gives the output amount and output proportion of Block Picking, Cross District, High Velocity Picking, Floor Picking, Rack Picking and Inner Packing in 2012 by week. After mining these data, the trends of each pick type is shown as follow:

![Figure 3-1 Output Items Volume by Pick Type – Total](image)

Above graph shows that the trend of total amounts of output during 2012 is relevant flat and very close to 400000, which means that there is no big change of output amount by week.
However, the output items by picking type show that these are obvious differences and fluctuations between different picking types. Inner Packing handles the least volume of tonnage. Cross District, Rack Picking and Floor Pick remain the middle. High Velocity Picking and Block Picking still stay the highest tonnage. In addition, the Block Picks always come out of High Velocity. This picking type is used in High Velocity area for items which has reserves by pallet quantity in the warehouse. In other words, it is an efficient way to move high volume items with pallet unit during cross docking process. So even the amount of High Velocity Picking is decreasing, it is hard to say the total amount of items in High Velocity Picking area is decreasing or increasing. It means that it is possible to treat both of High Velocity Picking and Block Picking together, and to analyze the trend of total amount of items in HV area. This is shown as follow:
The green line is the total tonnage amount of High Velocity items and Block Picking items, which can almost represent the tonnage amount of cross docking items. The trend of tonnage amount of cross docking is fluctuating but keeps in the region of 150000 and 200000 tonnages. So, based on the total tonnage amount, it is hard to say that the trend of cross docking is increasing or decreasing. This result also fits Floor picking and Inner pack picking area. However, the total amount of Rack Picking type is decreasing slightly.
Figure 3-4 Tonnage Proportion of each Picking Type

The above graph shows the proportion of tonnage amount of each picking type during 2012 first quarter. This can be used for trend forecast of each picking type in the future. From the graph, the trend of each picking type is relevant flat. The High Velocity area has increased a little, and the Rack Picking area has decreased slightly. The graph means that there is no big change for each tonnage amount during first quarter.
Density Factor

The pre-requisite of this project is redesigning the warehouse for future use, which can process double amount of inventory. So it is necessary to check the density factor about these key redesign areas: floor Picking, Rack Picking and High Velocity Picking area. Two kinds of density factors will be presented below: the first is average density factor, which means the average case amount per foot square, including the aisle space in these areas; the second is average density per pallet, which measure the average case amount per pallet instead of the area’s foot square. All factors are based on the assumption that the case size is not a considerable effect.

The result is shown as follow:

Table 3-2 Current Density Factor

<table>
<thead>
<tr>
<th>Area</th>
<th>Case / SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Picking</td>
<td>0.79 (0.68 plus Seasonal SF)</td>
</tr>
<tr>
<td>Rack Picking</td>
<td>2.49</td>
</tr>
<tr>
<td>High Velocity</td>
<td>2.96</td>
</tr>
</tbody>
</table>

Based on the trend forecast above, since there is no significant decrease or increase for any pick type, or due to small sample size, the tonnage percentage trend of each type keeps the same. So one assumption has to be made, which is that in this redesign warehouse project, the percentage tonnage amount of each picking type will keep the same in the future. It means that the total inventory of each type will be doubled. The average density factor per square foot is shown as follow:
Based on current construction, the floor picking can hold 0.79 cases per square foot, which means that 1.58 cases per square foot will need 2 levels. The same assumption can be applied to other picking areas. However, the Rack picking area is fully loaded; it is hard to add more rack without expanding space. One way to solve this problem is to move these additional items to floor picking area. The follow tables show the distribution after double inventory and modification which are based on the assumption that all additional Rack Picking inventory are moved to Floor Picking area.

Table 3-4 Section Distribution after Double Inventory

<table>
<thead>
<tr>
<th>Area</th>
<th>Map Number</th>
<th>Size (Square Foot)</th>
<th>Pallets</th>
<th>Pallets/Sq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rack Picking</td>
<td>8</td>
<td>40250</td>
<td>3446</td>
<td>0.084</td>
</tr>
<tr>
<td>Floor Picking</td>
<td>9</td>
<td>88750</td>
<td>2364</td>
<td>0.026 (Two Levels)</td>
</tr>
<tr>
<td>High velocity</td>
<td>10</td>
<td>37500</td>
<td>6866</td>
<td>0.182</td>
</tr>
<tr>
<td>Cross District</td>
<td>6</td>
<td>4000</td>
<td>166</td>
<td>0.040</td>
</tr>
<tr>
<td>Reduced Delivery</td>
<td>7</td>
<td>10000</td>
<td>2750</td>
<td>0.276</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>180500</td>
<td>15592</td>
<td>0.088</td>
</tr>
</tbody>
</table>

Table 3-5 Section Distribution after Double Inventory and Modification
From above tables, it is not hard to see that based on current area construction; the floor picking area can consume the additional inventory for both rack picking area and floor picking area. And four-level height rack is also a reasonable height in warehouse.
Chapter 4

Results and Evaluation

The result of the tonnage trend analysis, density factor and future growth found that due to the loose arrangement in High Velocity and Floor Picking area, the redesign process is mostly focused on these two areas. There are two proposals for each area, which will be presented as follow:

For the floor picking area, since there are so many cubic spaces can be used for future growth, so the main problem is how to utilize these cubic spaces. The first option is divide a part of floor picking area for Rack picking. Since the rack picking has almost fully loaded, it is hard to add more inventory to current system. This part of floor picking area is for these medium and slow movers only. In addition, the floor picking area also needs more racks for medium and fast movers. This method divides the floor picking area into two independent areas, one part consumes the additional Rack picking inventory, and another consumes the additional floor picking inventory. If this method is approved, there are four levels rack system will be installed in floor picking area and all racks are single deep rack which can create more primaries for different item.

The second option is mix rack picking and floor picking area as one. Since both of them need rack to expand storage space, the advantage of mix rack picking and floor picking is it can maximize the picking speed by using the lower rack level space for medium and fast movers, and put slow mover on the top of rack. Since the quantity of fast mover is large more than slow mover, it is convenient for operator to replenish fast inventory. In addition, since operators do not need to go too high for fast and medium movers, it also can reduce the power charge for equipment and working time.
The second part is the High Velocity area, which is almost used for cross docking operation. The arrangement in HV area is very loose right now. See at Appendix C. In order to improve the operation, two options have been proposed as follow:

The first option is build conveyor system at High Velocity area to improve the efficiency of cross docking process. The conveyor system can significantly raise the efficiency of cross docking process with less human labor work. However, it is a completely new construction in this warehouse; the switch cost of operator and the initial installment cost are relevant high. Moreover, there are still some items which cannot be conveyed. They need to be carried by forklift and operator manually. So it is better to balance the benefit between the process reduction and the learning cost plus installment cost, and the impact of current operation before start the conveyor system.

The second option is rearrange current HV area to contain more items. Right now, there are two lines of pallets with horizontal wide aisles to support 3 pallet jacks and three vertical aisles to go up and down. Each line contains two small lines of pallets. It shows as follow:

![Illustration of Current High Velocity area](image.png)

Figure 4-1 Illustration of Current High Velocity area
In order to increase the capacity, two dimensions growth is proposed: first, reduce the gap between the two small lines of pallets, and then reduce the wide aisle to just support two pallet jacks. Since the total amount of pallet jacks is not too much, there is enough space for third pallet jacks snake through the horizontal aisles. This method will create one more line for pallets for store use in future. Secondly, build one stage rack on each pallet. These racks are used for the replenishment of cross docking items. It can not only double the cross-dock capacity but also reduce the time to collect cross-dock replenishment. So, this option also can enhance HV capacity and process speed at the same time.

The above result shows that there are two modification options for each of Floor picking area and High velocity area. The combinations are showing as follow:

Table 4-1 Alternatives after Combination

<table>
<thead>
<tr>
<th>High Velocity Area</th>
<th>Rack picking and Floor picking Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I: Split Floor Picking area &amp; Build Conveyor</td>
</tr>
<tr>
<td></td>
<td>II: Split Floor Picking area &amp; Shrink HV aisle</td>
</tr>
<tr>
<td></td>
<td>III: Mix Rack and Floor Picking &amp; Build Conveyor</td>
</tr>
<tr>
<td></td>
<td>IV: Mix Rack and Floor Picking &amp; Shrink HV aisle</td>
</tr>
</tbody>
</table>

In order to better evaluate these alternatives, the following form is proposed:
<table>
<thead>
<tr>
<th></th>
<th>Space Utilization</th>
<th>Ease of Access</th>
<th>Cost of Implementation</th>
<th>Long-Term Viability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative I</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Alternative II</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Alternative III</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Alternative IV</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>weight</th>
<th>Space Utilization</th>
<th>Ease of Access</th>
<th>Cost of Implementation</th>
<th>Long-Term Viability</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative I</td>
<td>0.4</td>
<td>0.35</td>
<td>1.4</td>
<td>0.1</td>
<td>2.25</td>
</tr>
<tr>
<td>Alternative II</td>
<td>0.2</td>
<td>1.05</td>
<td>0.7</td>
<td>0.3</td>
<td>2.25</td>
</tr>
<tr>
<td>Alternative III</td>
<td>0.8</td>
<td>0.7</td>
<td>0.35</td>
<td>0.2</td>
<td>2.05</td>
</tr>
<tr>
<td>Alternative IV</td>
<td>0.6</td>
<td>1.4</td>
<td>1.05</td>
<td>0.4</td>
<td>3.45</td>
</tr>
</tbody>
</table>

The evaluation form shows that the Alternative IV owns the highest score, which means that combine the Rack and Floor pick area and rearrange the aisles in HV picking is a better modification to fit the future growth under the assumptions.
Chapter 5

Conclusion

The current inventory at Pottsville warehouse is out of its capacity, although it is able to complete all the operations. It is very necessary to redesign the facility and catch up with future business growth. The results show that the alternative IV would provide an effective and enduring option to fit the inventory requirement of future five to ten years growth at a relevant low initial cost. Combination of the additional Rack Picking inventory and Floor Picking inventory and rearrangement of the High Velocity is the key to improve efficiency and save money and time for Wegmans. So, the implementation of an alternative such as the proposed could allow Wegmans pursue the expansion and keep the same facility at the same time.

This project accomplished the objectives stated in the introduction. Four alternatives were proposed based on the limited data and resources and one of them stood up after evaluation. This alternative which is related with Rack Picking, Floor Picking and High Velocity Picking area can improve the processes of cross docking, put-away, order picking, replenishment, and packaging and shipping. Moreover, all the improvements are under the consideration of minimizing the change of facility layout and interruption of current business.

If this projected were to be considered again, it would be beneficial to forecast the future growth proportion of each type of inventory based on more transaction data and the ordering policy. It is possible to relieve current inventory pressure by mining transaction data and establishing better order policies. In addition, it would also make this redesign project more detailed and complete.
Appendix A

Current RSC Grocery Layout by Zones
## Output Items Volume by Picking Type

<table>
<thead>
<tr>
<th>Date</th>
<th>Block Pick</th>
<th>%</th>
<th>Cross Dist</th>
<th>%</th>
<th>High Velocity</th>
<th>%</th>
<th>Floor Pick</th>
<th>%</th>
<th>Rack Pick</th>
<th>%</th>
<th>Inner Pack</th>
<th>%</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>31-Mar</td>
<td>73,066</td>
<td>22.94%</td>
<td>54,073</td>
<td>16.98%</td>
<td>85,872</td>
<td>26.97%</td>
<td>35,646</td>
<td>11.19%</td>
<td>43,795</td>
<td>13.75%</td>
<td>26,001</td>
<td>8.16%</td>
<td>318,453</td>
<td></td>
</tr>
<tr>
<td>24-Mar</td>
<td>71,840</td>
<td>23.53%</td>
<td>49,357</td>
<td>16.17%</td>
<td>83,618</td>
<td>27.39%</td>
<td>34,546</td>
<td>11.32%</td>
<td>39,703</td>
<td>13.01%</td>
<td>26,225</td>
<td>8.59%</td>
<td>305,289</td>
<td></td>
</tr>
<tr>
<td>17-Mar</td>
<td>86,822</td>
<td>23.06%</td>
<td>54,431</td>
<td>14.46%</td>
<td>113,209</td>
<td>30.07%</td>
<td>45,282</td>
<td>12.03%</td>
<td>50,602</td>
<td>13.44%</td>
<td>26,162</td>
<td>6.95%</td>
<td>376,508</td>
<td></td>
</tr>
<tr>
<td>10-Mar</td>
<td>74,668</td>
<td>20.10%</td>
<td>55,273</td>
<td>14.88%</td>
<td>112,757</td>
<td>30.35%</td>
<td>46,337</td>
<td>12.47%</td>
<td>54,320</td>
<td>14.82%</td>
<td>28,192</td>
<td>7.59%</td>
<td>371,547</td>
<td></td>
</tr>
<tr>
<td>3-Mar</td>
<td>73,759</td>
<td>20.05%</td>
<td>55,829</td>
<td>15.17%</td>
<td>113,072</td>
<td>30.73%</td>
<td>47,078</td>
<td>12.80%</td>
<td>52,442</td>
<td>14.25%</td>
<td>25,742</td>
<td>7.00%</td>
<td>367,922</td>
<td></td>
</tr>
<tr>
<td>25-Feb</td>
<td>78,058</td>
<td>20.83%</td>
<td>58,676</td>
<td>15.66%</td>
<td>110,691</td>
<td>29.54%</td>
<td>48,168</td>
<td>12.86%</td>
<td>52,987</td>
<td>14.14%</td>
<td>26,112</td>
<td>6.97%</td>
<td>374,692</td>
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<tr>
<td>18-Feb</td>
<td>76,549</td>
<td>20.83%</td>
<td>56,996</td>
<td>15.51%</td>
<td>108,892</td>
<td>29.63%</td>
<td>45,302</td>
<td>12.33%</td>
<td>52,025</td>
<td>14.16%</td>
<td>26,281</td>
<td>7.53%</td>
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<tr>
<td>11-Feb</td>
<td>82,915</td>
<td>22.38%</td>
<td>56,819</td>
<td>15.34%</td>
<td>107,096</td>
<td>28.91%</td>
<td>44,203</td>
<td>11.90%</td>
<td>53,050</td>
<td>14.32%</td>
<td>26,329</td>
<td>7.11%</td>
<td>370,412</td>
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<tr>
<td>4-Feb</td>
<td>75,380</td>
<td>20.06%</td>
<td>56,576</td>
<td>15.05%</td>
<td>117,283</td>
<td>31.21%</td>
<td>45,512</td>
<td>12.11%</td>
<td>58,958</td>
<td>15.68%</td>
<td>22,144</td>
<td>5.89%</td>
<td>375,831</td>
<td></td>
</tr>
<tr>
<td>28-Jan</td>
<td>74,017</td>
<td>20.15%</td>
<td>52,203</td>
<td>14.21%</td>
<td>104,525</td>
<td>28.46%</td>
<td>43,425</td>
<td>11.82%</td>
<td>55,478</td>
<td>15.11%</td>
<td>37,608</td>
<td>10.24%</td>
<td>367,256</td>
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<tr>
<td>21-Jan</td>
<td>84,202</td>
<td>21.62%</td>
<td>58,577</td>
<td>15.04%</td>
<td>115,697</td>
<td>29.71%</td>
<td>47,787</td>
<td>12.27%</td>
<td>58,961</td>
<td>15.14%</td>
<td>24,217</td>
<td>6.22%</td>
<td>389,441</td>
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</tr>
<tr>
<td>14-Jan</td>
<td>78,566</td>
<td>21.11%</td>
<td>55,950</td>
<td>14.94%</td>
<td>111,930</td>
<td>30.07%</td>
<td>43,804</td>
<td>11.77%</td>
<td>58,404</td>
<td>15.69%</td>
<td>23,899</td>
<td>6.42%</td>
<td>372,183</td>
<td></td>
</tr>
<tr>
<td>7-Jan</td>
<td>63,866</td>
<td>18.79%</td>
<td>53,797</td>
<td>15.83%</td>
<td>102,905</td>
<td>30.28%</td>
<td>39,599</td>
<td>11.62%</td>
<td>58,512</td>
<td>17.22%</td>
<td>21,275</td>
<td>6.26%</td>
<td>339,864</td>
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<tr>
<td>totals  2012</td>
<td>993,708</td>
<td>21.16%</td>
<td>718,197</td>
<td>15.29%</td>
<td>1,387,547</td>
<td>29.54%</td>
<td>566,599</td>
<td>12.06%</td>
<td>689,215</td>
<td>14.67%</td>
<td>341,577</td>
<td>7.27%</td>
<td>4,696,843</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C

Arrangement in High Velocity area
References

6. Rolando Jose Vetencourt Stull, 2004, Redesign Warehouse Plant Layout For A Food Company

Minimizing the Order Picking Costs under real-life Constraints.