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An Evaluation of Pesticide and Disposal Structures Appropriate to the Needs of the Southern Illinois University Farms: A Review of the Literature

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AN EVALUATION OF PESTICIDE STORAGE AND DISPOSAL STRUCTURES APPROPRIATE TO THE NEEDS OF THE SOUTHERN ILLINOIS UNIVERSITY FARMS: A REVIEW OF THE LITERATURE

By

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A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
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Approved by:

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TITLE: AN EVALUATION OF PESTICIDE STORAGE AND DISPOSAL STRUCTURES APPRORIATE TO THE NEEDS OF THE SOUTHERN ILLINOIS UNIVERSITY FARMS: A REVIEW OF THE LITERATURE

MAJOR PROFESSOR: Dr. Seburn Pense

Agronomic research at Southern Illinois University and many research parks around the world require the use of pesticide application. As environmental issues seem to progress, the need to safely handle, store, and dispose of chemical waste is growing. Federal regulations are in place to provide the guidelines that direct these practices now but, the enforcement of these rules is lacking. Information seems to be dated and the universal answer is vacant to solve this challenge.

In order to fully protect the environment and the people that work around pesticides, further research on structures capable of handling this material is needed. The purpose of this study is to evaluate pesticide storage and disposal structures and how their use falls under the regulatory guidelines provided by the USEPA. This evaluation, along with information pertaining to the topic of a pesticide storage/mixing and disposal center, will help determine what the needs are for Southern Illinois University.

Keywords: pesticide storage, EPA regulations, pesticide disposal

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TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Illinois is a state known for agronomic and horticultural crop production with a great diversity of crops produced. The state is a leading producer of both corn and soybeans and also produces several specialty crops, of which it holds the title of being the number one producer of pumpkins in the country and is also the world leader in horseradish production (Illinois Department of Agriculture, 2014a). In order to successfully grow these crops and meet market demands, pest management is crucial. Many growers choose chemical approaches for increasing yields to meet the demands of a growing world population. When choosing to control problems by chemical means, many producers have pesticides custom applied or make applications themselves. The concern, when choosing the chemical approach, is how to properly dispose of any leftover chemical in the tank and what to do with the rinsate? The mismanagement of generated waste pesticide materials may cause potential environmental problems (Schmidt et al., 1987; Illinois Environmental Protection Agency, 1982), As a state entity, University Farms should be leading the way in proper management by having structures that meet current and proposed federal and state EPA requirements.

While the Agronomy Research Center (ARC) at Southern Illinois University-Carbondale conducts a great deal of research in crop science that requires the use of pesticides, the facilities to store and handle chemicals are either outdated or barely meeting the standards that the Federal Insecticide, Fungicide and Rodenticide Act stipulate. There are over 53 research plots alone at the ARC covering approximately 80 acres of row crops. Throughout the entire crops research that takes place, crops such as corn, soybeans, wheat, sorghum, grapes, apples, and many small fruits and vegetables are sprayed; creating an abundance of rinsate that will need to be disposed of. Evaporation pits have been used in the past and do seem to work in the separation of water from the chemical sludge, but the sludge that remains poses other issues. Other studies conducted at SIU have included the experimentation with acidic and alkaline trickling systems that were assessed for biological and chemical decomposition of pesticides (Schmidt et al., 1987; Illinois Environmental Protection Agency, 1982).

Not all pesticides will blend together and potential chemical waste interactions could occur, leaving larger problems. So again, what is the proper means of disposal of leftover tank mixes and herbicides? This is a constant problem that is encountered at the ARC because of the special detail and requirements of each research plot and meeting the challenge is something that sooner or later will have to be addressed. Unlike those practices strictly used in production agriculture, research plots require special tank mixtures and applications. These are applied at different times and in some instances multiple crop species are sprayed the same day, requiring different pesticides. Having these individual and specialty tank mixes sprayed throughout the day has led to a buildup of leftover pesticide waste and also tank residue that needs to be removed and contained. Though many farmers themselves face a similar issue, our challenge revolves around the number of specialty tank mixes throughout the day compared to the likelihood of a single spray mix that producers would most likely be applying in a single day.

Statement of Problem

While restrictive use pesticides hold an important role in production and research agriculture, the standards for their safe storage and disposal should remain as vital as the knowledge needed to properly apply them. Several questions should be considered in regard to storage and disposal.

- Does proper training alone provide the best solution for ensuring the appropriate means of storage and disposal?
- Are the pesticides used being stored in the proper manner?
- With current storage practices, is there an assurance that there is a full protection from environmental contamination?

Purpose of the Study

The purpose of this study is to explore opportunities in pesticide and chemical handling that provide for safer and more universal standards to protect both the handler as well as the environment. Information was gathered through the examination of research articles, extension bulletins, and governmental literature in the hopes of establishing a universal and more secure method of pesticide storage and disposal. Discussion on the issues of the accumulation of pesticide waste, potential concerns of the waste, what disposal system would best fit research program needs, and what considerations are needed to build a structure that is capable of meeting those needs.

Objectives

1. Determine what pesticide waste is and how it accumulates in small plot research.
2. Discuss the potential concerns of pesticide waste.
3. Express why disposal systems have importance.
4. Review and discuss past and current regulatory efforts revolving around pesticide storage and disposal.
5. Evaluate structure considerations that are needed to for storage and disposal.
6. Discuss important points involved in site selection.
7. Assess the chemical and general storage precautions.

8. Lay out specifications for a mixing/loading pad.

Limitations

Limitations found in this paper are comprised of multiple points and include the lack of current research to provide up to date information. Most of the information revolving around this topic are 20-30 years old and may not meet the standards modern regulations have on the industry. Even if more current data points were available for this topic, one other limitation is the continued problem of a universal standard. Federal and state laws govern the guidelines for safe handling, usage, storage and disposal; but, as far as a true standard of how storage/disposal structures should be built is absent. Multiple states have built and evaluated what specifics need to be thoroughly examined but, all are slightly different.

Definition of Terms

To ensure proper understanding of key terms used throughout the discussion, the following terms have been defined:

FIFRA: The Federal Insecticide, Fungicide, and Rodenticide Act; the federal statute that governs the registration, distribution, sale, and use of pesticides in the United States (U.S. Environmental Protection Agency, 2016a).

Herbicide: Herbicides are chemicals used to destroy unwanted plants (terrestrial or aquatic) called weeds (Martin & Martin, 2004)

Mixing Pad: A specific area that is designed for the transfer of chemicals from the storage area to the application equipment that contains a sump and a set of tanks to hold water containing pesticide solutions that provides containment in the case of leaks, spills or rainfall accumulate (Sumner & Bader, 2009).

Mode of Action: The general way in which a pesticide affects a pest (Paulsrud et al., 2003).

Pesticide: Any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs or which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies (Jeyaratnam, 1990).

Phytotoxicity: Being injurious or lethal to plants (Paulsrud et al., 2003).

Restrictive Use Pesticides: This is a classification that restricts a product, or its uses, to use by a certified applicator or someone under the certified applicator's direct supervision (U.S. Environmental Protection Agency, 2016c).

Site of Action: The specific cellular or molecular processes (for example ALS enzyme) that are affected within a pest when a pesticide is applied. For some pesticides the site of action is unknown (Paulsrud et al., 2003).

Rinsate: Rinsate is a mixture of pesticides diluted by water, solvents, oils, commercial rinsing agents or any other substances. It is produced from cleaning pesticides application equipment or pesticides containers (NSW Environmental Protection Authority, 2012).

Triple Rinsing: A method of washing a pesticide three times so that almost all of the pesticide residue is removed (Paulsrud et al., 2003).

Weed: Any plant which grows where not wanted (Federal Insecticide, Fungicide, Rodenticide Act, 2012).

CHAPTER 2

REVIEW OF LITERATURE

Background

Each spring temperatures rise and farmers begin preparing for the coming cropping season. Management practices are crucial in this preparation and one of these tools is the use of pesticides to protect the crop. It is because if this usage that research should be conducted in determining the safety of storage and disposal of pesticides used. The purpose behind this article is the evaluation of and exploration of factors within pesticide waste and its potential concern, the importance of a disposal system, what regulations are available that need to be followed and met, as well as infrastructure needs and requirements that would fit into the University Farm system at Southern Illinois University, Carbondale.

From spring to mid-summer, pesticide application is a common occurrence throughout many fields in and around southern Illinois. Pesticide use is expanding throughout the world, and in 1991 U.S. retail sales were $7.8 billion (Yoder et al., 2001). The National Agricultural Statistics Service (NASS), a part of the United States Department of Agriculture (USDA), provides information and the numbers that represent the total pesticides used. It classifies chemicals as herbicide, insecticide, or fungicide, and also gives a detailed look at the amounts of the top herbicides used based on specific crops, while providing the exact percentage of planted acres treated with those herbicides. For the 2014 cropping year in corn, 97 percent of the planted corn acres were sprayed with herbicides while only 13 and 12 percent of those exact acres were covered with insecticides and fungicides (Figure 1). While these numbers only were a representation of the top corn producing states, they make up nearly 89 percent of the total US acres planted to corn (United States Department of Agriculture, 2015). Illinois itself accounts for 13.1 percent of total corn production acres, only behind Iowa (United States Department of Agriculture, 2015). Among herbicides, atrazine was the most widely used active ingredient (applied on 55 percent of planted acres), followed by glyphosate isopropylamine salt (38 percent) (Figure 2).

The statistics for soybeans were similar to corn. For the 2012 soybean crop; herbicides were used the most extensively, applied to 98 percent of soybeans acres while insecticides and fungicides were applied to 18 percent and 11 percent of planted acres, respectively (Figure 3). Among herbicides, glyphosate potassium salt was the most widely used (59 percent of planted acres), followed by glyphosate isopropylamine salt (30 percent) (Figure 4).

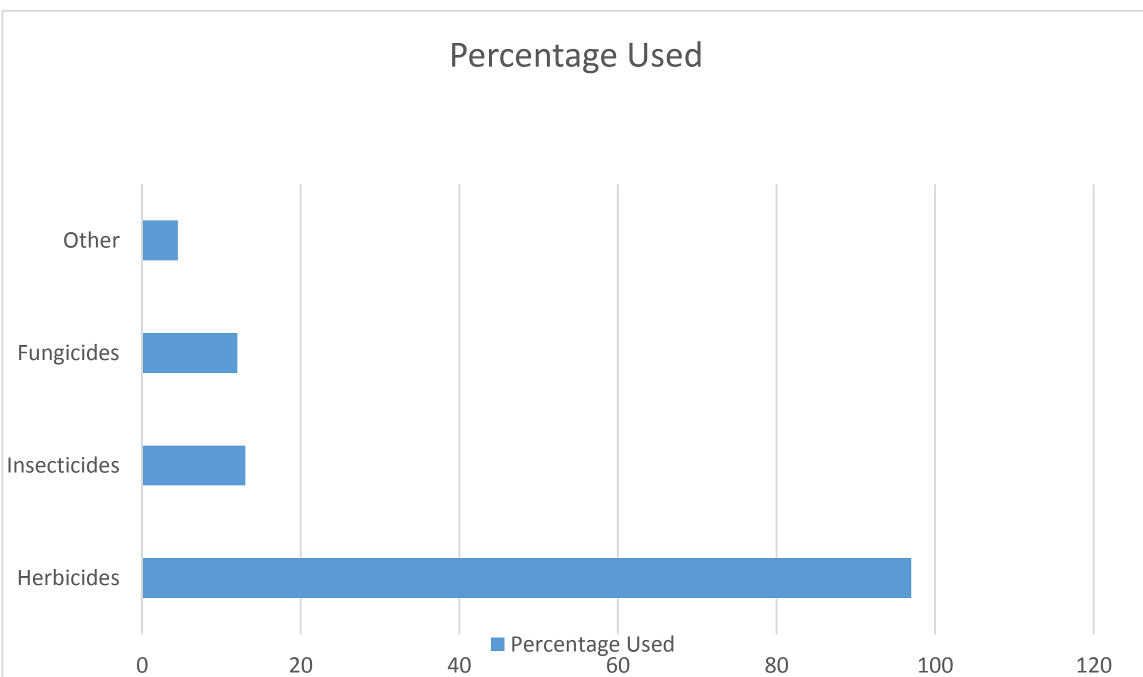

Figure 1. Corn pesticides used (% planted acres) in 2014 crop (United States Department of Agriculture, 2015)

Active Ingredient	% of Planted Acres	Avg. Rate for Year (lbs/acre)	Total Applied (mil lbs)
Atrazine	55	1.018	45.2
Glyphosate isopropylamine salt	38	0.889[a]	27.2[a]
Acetochlor	29	1.256	28.7
Mesotrione	27	0.115	2.5
S-Metolachlor	27	1.106	23.6
Glyphosate potassium salt	24	1.159[a]	22.6[a]

[a] Expressed in acid equivalent

Figure 2. Top herbicides used for the 2014 corn crop (United States Department of Agriculture, 2015)

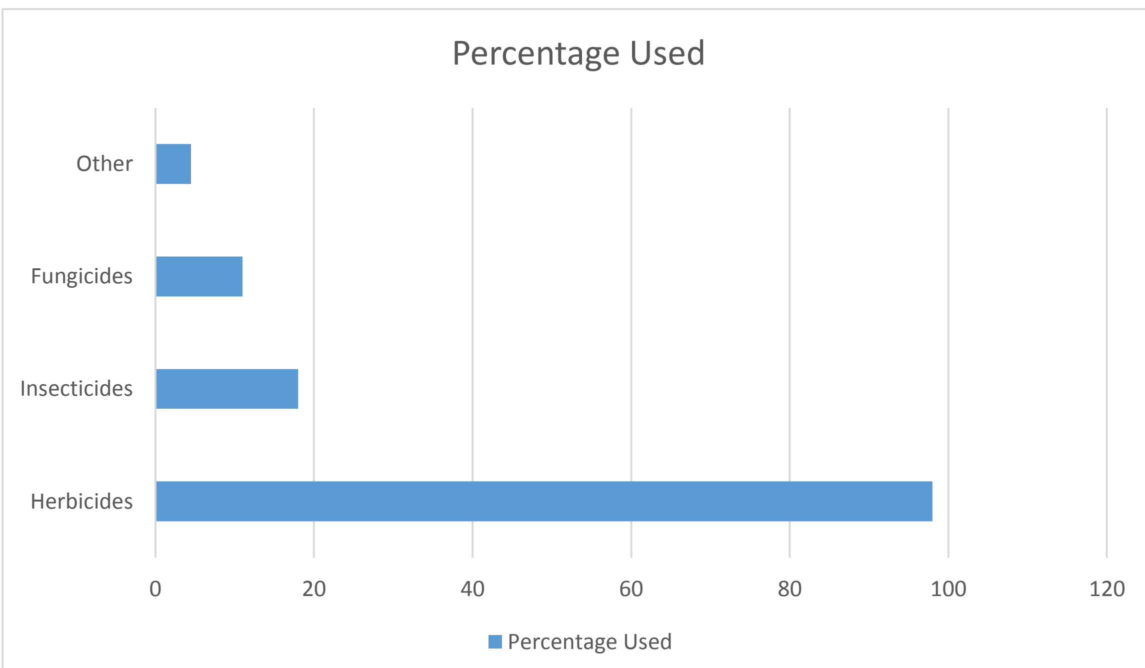

Figure 3. Soybean pesticide used (% planted acres) for 2012 crop (United States Department of Agriculture, 2013)

Active Ingredient	% of Planted Acres	Avg. Rate for Year (lbs/acre)	Total Applied (lbs)
Glyphosate potassium salt	59	1.628	70,826,000
Glyphosate isopropylamine salt	30	1.330	29,550,000
Chlorimuron-ethyl	11	0.023	187,000
2,4-D, 2-EHE	11	0.519	4,098,000
Flumioxazin	11	0.076	602,000

*The period starting immediately after harvest of the previous year's crop and ending at harvest of the current year's crop.

Figure 4. Top soybean herbicides used in 2012 crop (United States Department of Agriculture, 2013)

Pesticide Waste

Large fields containing one crop make mixing and cleaning of herbicides very simple, or at least simpler than in small plot research. Within small plot research, several crops might be covered in one day by the use of one machine. Not all of these crops can be sprayed with the same herbicide and constant cleaning and rinsing is an everyday occurrence, leading to the accumulation of pesticide waste and rinsate.

Pesticide waste is considered any substance or material containing pesticide that cannot or will not be used and therefore must be disposed of (Damalas et al., 2008). Pesticide waste includes surplus spray solutions, pesticide leftover which remains in the application equipment after use, pesticide-contaminated water produced by cleaning the application equipment or from rinsing the empty pesticide containers, pesticide-contaminated materials generated from cleaning up spilled pesticides, empty (unrinsed) pesticide containers, and old pesticide products (Nesheim & Fishel, 2005).

Potential Concerns of the Waste

The unfortunate truth is all of these sources are a challenge to dispose of every year. This is a problem that has been faced in the past and will continue to be faced in the future if nothing is done to address it. Generations of pesticide waste of various kinds is often inevitable in almost every agriculture operation from storage, to use, and to equipment cleanup (Felsot et al., 2003).

The problem with pesticide waste is that people must find a way to dispose of it even if appropriate facilities are not available; and an ongoing challenge within the industry is the absence of a universal solution. Again it is the mismanagement of generated waste pesticide materials which may cause potential environmental problems: the contamination of ground and surface water via runoff from the site of pesticide mixing, and/or discharges of chemical spray tank rinsates into streams (Schmidt et al., 1987; Illinois Environmental Protection Agency, 1982). What individuals or businesses in one part of the country perceive as common practice for disposal potentially could be very different in other parts. Research on how to best deal with pesticides dates back to the 1970s (Yoder et al., 2001). Many options have been examined but none has emerged as the widely accepted solution and these approaches have been environmentally unsound, too complicated, too expensive to appeal to most applicators, or they require an unacceptably high level of management (Yoder et al., 2001).

In the past, operators and applicators of pesticides might have simply dumped left over tank mixes or chemical into rocks, ditches, fence rows or other places not specified for disposal. Handling pesticide contaminated water can become complex but unfortunately, the simplest alternative is to open the drain on the spray tank while traveling back from the field, or to otherwise apply excess in possible violation of application limits (Yoder et al., 2001). Accidental release or uncontrolled discharge of pesticide waste into the environment can harm people and contaminate the environment (Damalas et al., 2008). Pesticide-contaminated water poses a great hazard to non-target organisms such as plants, beneficial insects, fish and other aquatic life (Damalas et al., 2008).

It's not just the "accidental" release that causes potential problems though. Unwanted pesticides that are improperly stored also represent potential sources of environmental contamination (London, 1994; Skinner et al., 1997; Spitzmueller, 1994). Along the flood plains of the Mississippi, Illinois, and Kaskaskia Rivers, there are about 80+ agrichemical facilities where pesticides and/or fertilizers are stored and mixed for distribution to farmers (Roy et al., 1995). This contamination threat is a major concern and natural disasters such as the flood of 1993 along the Mississippi River posed a major threat to unwanted movement and potential pesticide contamination in unwanted areas.

A number of approaches are available to assist in the reduction of contamination, including: (1) washing of spray equipment in the field thus reducing the requirements for decontamination at the farmyard and the disposal of any associated waste; (2) better design of the farmyard to minimize release of pesticides to nearby surface water; or (3) treatment systems that are installed on the farmyard to treat any waste arising from spray equipment and during the filling process (Fogg et al., 2003).

Because the quality of surface and groundwater is a major concern in both rural and urban areas, a comprehensive study of the occurrence of pesticides in soil materials at agrichemical facilities in Illinois was conducted (Krapac et al., 1994). In general, the pesticides detected most often were herbicides, which were also the most commonly used in Illinois and most often at agrichemical facilities (Krapac et al., 1994). As stewards of the land on which farmers/growers work, it is their duty to see to it that the soil, water and other natural/agricultural ecosystems are taken care of for future use.

Importance of Disposal Systems

For many years, agricultural producers have disposed of many solid waste products on their farmsteads (Reed et al., 2000). Urbanization concerns mean less ground available for agricultural use so proper management is absolutely crucial. A study of agrichemical safety practices in the western Cape of South Africa (London, 1994) concluded that, ‘In the absence of a system of pesticide disposal, the presence of residual, unwanted and outdated stocks of pesticides in farmers’ stores, and in another article, to a lesser extent the presence of empty containers, are identified as important problems’ (Gunter & Centner, 2000). In 1993, the U.S. Environmental Protection Agency (EPA) estimated that more than 13 million pounds of unwanted pesticides were located in six Great Lakes States alone (Jones, 1993). These large numbers are daunting.

Regulatory Efforts

Like many other endeavors to help clean up and control future problematic issues, information has to be collected and analyzed and a plan must be designed and put forth. In 1947, the U.S. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was enacted and in its attempts for regulatory efforts allowed states to administer state pesticide programs (Carriker, 1996), and one of the powers granted under state regulations is to regulate the disposal of pesticides (Gunter & Centner, 2000). FIFRA itself is; the federal statute that governs the registration, distribution, sale and use of pesticides in the United States. With certain exceptions, a pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, or intended for use as a plant regulator, defoliant or desiccant, or any nitrogen stabilizer (U.S. Environmental Protection Agency, 2016b).

Originally, FIFRA required that persons register pesticides distributed in interstate commerce with the United States Department of Agriculture (USDA) and establish a rudimentary set of labeling provisions (U.S. Environmental Protection Agency, 2016b). In 1972 the Federal Environmental Pesticide Control Act amended FIFRA as did the Pesticide Registration Improvement Act of 2003 (U.S. Environmental Protection Agency, 2016b). These acts of legislation stipulated the following:

- Strengthen the enforcement of FIFRA
- Broaden the legal emphasis on protecting the health and environment
- Regulate the use of pesticides
- Extend the scope of federal law to cover intrastate registration
- Streamline the administration appeals process

The regulatory process was able to push these provisions through for the insurance of the safe use, handling and transport of pesticides and other chemicals. The original agency that was responsible for administering FIFRA was the USDA until 1970 when the formation of the Environmental Protection Agency (EPA) shifted FIFRA's control (U.S. Environmental Protection Agency, 2016b). FIFRA now stipulates that the EPA has the authority to establish regulations and procedures regarding pesticide storage and disposal, and Section 19 of FIFRA authorizes the EPA to collect information and establish requirements for the storage, disposal, transportation and packing of pesticides (U.S. Environmental Protection Agency, 2016b). All of this is done to protect public health and to ensure its overall safety.

Though the EPA has the overall control in FIFRA, each state is given the primary responsibility of enforcement under FIFRA §26 for pesticide use violations if the EPA determines that such a state has adopted and is implementing adequate pesticide use laws and regulations, enforcement procedures record keeping and reporting requirements (U.S. Environmental Protection Agency, 2016b). Under FIFRA, States have the broad authority to regulate pesticides; however, it is unlawful for states to impose or continue to affect any requirements for labeling or packaging in addition to, or different from, those required under FIFRA (U.S. Environmental Protection Agency, 2016b).

Though each state has the right to develop their own program, each program must comply with federal hazardous waste provisions within the Resource Conservation and Recovery Act (RCRA) (Gunter & Centner, 2000). The RCRA gives EPA the authority to control hazardous waste from the “cradle-to-grave”, this includes the generation, transportation, treatment, storage and disposal of hazardous waste and the RCRA also set forth a framework for the management of nonhazardous solid waste (U.S. Environmental Protection Agency, 2015). This helps to keep checks and balances among the state programs and insures that they will follow all federal boundaries.

Excess pesticide waste is the concern and in order to best overcome disposal challenges knowledge of farmers’ attitudes towards disposal of pesticide waste can be useful to uncover critical points of intervention to promote safety during pesticide handling and targeting specific need requirements for specific regions of pesticide use (Damalas et al., 2008). As mentioned before, this research goes to the 1970’s and it wasn’t until the late 1980s that 46 states had begun to develop pesticide collection programs to provide possessors of unwanted pesticides a safe and effective way of disposal (Cubbage, 1996; Spitzmueller, 1994). Thousands of farmers, since programs like this have been started, have voluntarily disposed of unwanted pesticides which has removed some of the threat of accidental spills (Gunter and Centner, 2000).

In Illinois, the Illinois Department of Agriculture and Illinois Department of Public Health have put together and operated the Illinois Clean Sweep Program, which has helped in efforts of reducing unwanted pesticides. According to the Illinois Department of Agriculture website (Illinois Department of Agency,2014b), as stated in the article *Pesticide Clean Sweep Program*, this program is funded by the USEPA and is usually hosted by Farm Bureau, Extension, and Soil Water Conservation offices. This program was started in 1990 and mandated all chemicals must be pre-registered, and has since collected more than 470,000 pounds of old, unwanted chemicals (Illinois Department of Agriculture, 2014b). These are the steps headed in the right direction; however, if excess pesticides are not the issue what can be done? For research facilities where multiple applications of multiple pesticides are being made in a single day, excess rinsate and tank mixes create a more complex issue.

When applying pesticides, it seems almost inevitable that an operator will have some excess pesticide. There are factors such as equipment speed, soil moisture, field area, operator error and other factors that change or effect the amount actually being applied to specific sites. In cases where excess tank mixes are found, what do you do with the leftover solution? Re-spraying treated areas with this excess solution is risky because it doubles the recommended rate on the crop which can result in several major problems such as crop damage (phytotoxicity), unacceptable residues in the harvested products, or harmful residues in the soil (Damalas et al., 2008). Pesticide labels spell out the specifics on how much can actually be applied within a single application or within one growing season.

Two pesticides that are commonly used in and around southern Illinois are the herbicides fomesafen and atrazine, both having residual effects that last for several months and can cause phytotoxicity to future crops that are planted. Atrazine [2-chloro-4-(ethylamino)-6-

(isopropylamino)-*s*-triazine] is one the most widely used herbicides in the United States (Kearney et al. 1988). In the 2014 crop season, atrazine comprised nearly 55 percent of the herbicides in corn, the most widely used active ingredient (U.S. Department of Agriculture 2015). The big concern with having excess atrazine is its impact on aquatic life and the fear that it will pollute groundwater and drinking water sources. Pesticide contamination of surface waters can arise from a number of sources though, including release from fields during and after the application process, leakage from equipment, spillage or incorrect disposal of waste pesticides and washings (Fogg et al., 2003).

The agriculture industry is a targeted source of water pollution; especially due to the intensification of agricultural practices, and particularly due to the growing use pesticides has had on increased impact to the quality of water, not only in developing countries but also in those that have been developed (Damalas et al., 2008). Safe disposal of pesticides in wastewater is a major problem for farmers, commercial applicators and small-scale formulators (Kearney et al., 1988).

Proper rates and timing of pesticide application do minimize the risk for environmental contamination however. Three common mistakes that occur and increase risk are: improper application; accidental spills during storage, mixing, or in the loading process; and the third, yet again, improper disposal (Yoder et al., 2001). The concerns of water sources being impacted have been going on for years. Unfortunately, there hasn’t been a clear solution yet. Continued research and regulation provisions are needed to insure the best answer.

Structure Considerations

The best solution to the problems related to excess rinsate and pesticide is to have a facility in which all can be safely stored, mixed and cleaned. The first thing to consider when designing and building a facility with this purpose is location. The purpose of a facility of this nature in southern Illinois is simple, provide a better and more effective way in mixing, loading, storing and containing pesticides and pesticide rinsate. Appendix II showcases a simple design for considerations. In designing a structure that meets the needs, it is important to take into account personnel and environmental safety and state and federal regulations (Sumner & Bader, 2009).

Before building can take place it is crucial to be current on these rules and regulations; this allows for the best site selection and that once in operation it will be fully compliant. Several points must be considered when selecting the site for pesticide storage. These factors would include: prevailing wind direction, especially downwind and downhill from sensitive areas like houses, play areas and animal feedlots and shelters; areas that are unlikely to flood, but in the case of flooding that water can be collected and treated as surplus pesticide (Schulze et al., 2001).

Site Selection

Site investigation should also be performed to determine any pre-existing contamination on the site and/or any open wells (Kammel & Noyes, 1994). Soil and water samples should be taken on the potential sites and tested for pesticides previously used in that location (Kammel & Noyes, 1994). Acting on information provided in past studies, the IEPA proposed, as an objective for soil cleanup, that the total pesticide concentration within the upper 15 cm of soil at agrichemical facilities not exceed 10 mg/kg (Krapac et al., 1994).

In addition, it is important not to build in areas that have been a huge environmental concern: water sources. The location chosen should be away from any source of water that could have the potential to become contaminated by any accidental spill (Ferrell & Aagard, 2003).

Since water purity has become such a hot topic it is crucial for these types of facilities to protect against any form of water contamination that could potentially occur. The flooding of 1993 created many environmental and ecological concerns on the impact of the flooding on the mobilization of agricultural chemicals such as pesticides and fertilizers, via flood waters and sediments, from areas of intended use to non-target areas (Roy et al., 1995).

In a situation like SIU where almost all of the chemicals come in small containers, the EPA states "For pesticides in small containers, such as 55-gallon drums or smaller containers, EPA regulates pesticide storage through specific storage instructions on pesticide labels" (U.S. Environmental Protection Agency, 2015a). For these types of structures to exist, several factors have to be considered and a few critical features must be met in order to successfully contain these pesticides.

Chemicals and General Storage Precautions

When working with pesticides, it is important to be familiar with the many forms they come in and this also means taking into consideration the supplies and means of cleaning any accidental spills. The most common types are herbicides, insecticides, fungicides, rodenticides, and fumigants, but there are many more (Ferrell & Aagard, 2003). Pesticides can be formulated as concentrates or as liquids that are ready to use; as solids such as dusts, wettable powders, and granules; or as gases in pressurized cylinders (Ferrell & Aagard, 2003). Depending on inventory size, a separate building, room or enclosure may be best for pesticide storage (Ogg et al., 2001) and in many cases farmers and, in the case of SIU, have been found to store farm chemicals on shelves or on wooden pallets (Reed et al., 2000).

According to Ferrell and Aagard (2003) there are several general precautions you should take in your storage management plan:

1. Store pesticides in their original, labeled containers and never in beverage, food, open, or other containers that could be mistaken for something else.
2. Keep pesticides out of the reach of children, pets, and livestock. A well-ventilated, dry, locked, and labeled cabinet or storage room is recommended.
3. Separate pesticides from foods, feeds, drugs, or other edible products and their packaging materials.
4. Separate pesticides from protective clothing and equipment.
5. Keep pesticides away from sources of flames or ignition and away from sources of water. Consider the potential for flooding, fire, or other disasters.
6. Store pesticides with lids tightened and periodically check for leaks or other problems.
7. Take precautions to keep labeling intact and legible. A label is a legal document, and if it becomes illegible, legal use of the product could be compromised.
8. Keep different classes of pesticides separate from each other (herbicides separate from insecticides, etc.).

Other points to consider are: securing the herbicide in a location where only trained and authorized personnel have access, storing pesticides in a room that limits UV exposure, and also having a climate controlled environment that allows for a balanced temperature year round. These precautions will assist in preventing the accidental spills and contamination of the surrounding environment and also securing the longevity of these pesticides. It is crucial to maintain a current inventory of all materials in storage, along with a label of all materials in a secure area away from the storage area (Sumner & Bader, 2009). It is important that chemicals left in these types of storage areas are dated and that they are used while their shelf life is at its fullest, meaning that the inventory should be rotated to maximize that shelf life (Ferrell & Aagard, 2003). Following these tips will help in evaluating how much space is actually needed for storage.

Mixing/Loading Pads

One feature that requires a great deal of attention to detail and requires very strict consideration is the mixing/loading pad that pesticide structures should have. Pads are not just important for the containment of chemicals before you go to the field, but also provide you a sense of security and a means of controlling the rinsate that is present after field applications. Mixing/loading pads consist of a pad containing a sump and a set of tanks to hold water (Sumner et al., 2009). Pads are used to collect and maintain spills from the handling and transfer of pesticides from storage to spray equipment (Kammel & Noyes, 1994). The surface, or pad, should be large enough to contain leaks from bulk tanks, to hold wash water from cleaning equipment, and to keep spills from transferring chemicals to the sprayer or spreader (Harris et al., 2006).

Due to the amount of chemical being used, a pad should be able to hold 110-125 percent of the volume of the largest tank within the containment area; these tanks include sprayer tanks or rinsate tanks (Sumner & Bader, 2009). These pads should also extend 5 feet on each side of the edges of the largest spray boom, when extended, to help contain back splash (Sumner & Bader, 2009). Because the purpose here is to load, mix, and control spills; rinsate on these pads is unavoidable. The load pad, in good practice, should be washed down daily during the spraying season (Kammel & Noyes, 1994). The pad should slope 2% towards the center of the pad so rinsate can collect on the pad and not wash off (Ferrell & Aagard, 2003).

Rinsate and left over field-strength chemical from the sprayer should be pumped into a marked rinsate tank (Ferrell & Aagard, 2003). Rinsate tanks should be cone bottom design or depressed outlet type tanks to allow complete draining of the tank and accumulated solids (Kammel & Noyes, 1994). For research needs, multiple tanks would be needed to contain pesticides specific to the crop being sprayed. Proper pad design and containment practices will decrease the potential for harming the ecological and environmental reactions. Appendix I provides detailed specifics lined out for the mixing and loading pad provided through the work of The University of Georgia Cooperative Extension Engineers Paul Sumner and Michael Bader. Appendix III shows a rough outline for a design that would best fit the SIU Farms, designed based off of the information gathered and read for this article.

CHAPTER 3

CONCLUSIONS & RECOMMENDATIONS

Conclusions

Illinois agriculture is an industry that greatly impacts people all over the world. Decisions that producers make in their operations don't only affect themselves but also those around them. Choosing to use pesticides for control measures has its advantages and disadvantages and by taking into consideration the impact they can have on the surrounding environment will lead to better use and management. There has been research conducted in the past but that is just the issue, it's in the past. The pesticide industry is always changing and because of this it is hard to create a general answer for pesticide disposal and storage but throughout this paper specific topics were chosen to fully understand what the problem is and how to proceed in the future.

Pesticide Waste

The first step is to identify what the problem is, pesticide waste. It accumulates in plot research as well as production settings through simple usage, cleanup, and storage. It is found in and around SIU Farms and is used year after year. In this article, it was not only defined, but examples on how it accumulates were given.

Potential Concerns of the Waste

The concern with this accumulation of pesticide waste around the SIU Farms is simple, it's the disposal process. Southern Illinois is surrounded by the Mississippi and Ohio Rivers and there are many tributaries throughout. As discussed, generations of pesticides have been used at SIU and many more generations to come. It is through the mismanagement of this waste that groundwater can become contaminated and affect not only the surrounding environment but also areas away from Southern Illinois. Poor disposal decisions have been used in the past that can cause concerning amount of environmental damage if not controlled.

Importance of Disposal Systems

These systems have such a huge impact on maintaining pesticide waste, rinsate, and unused chemical. In areas that a structure or systems was not available, it was shown that this waste was present. Controlling this and reducing the presence of unwanted pesticides is important, not only for environmental health but also for human health.

Regulatory Efforts

In the end, it is through the use of the federal guidelines that are in place to help unsure all is done accordingly. When it comes down to pesticides and their use, storage, and disposal; several laws are set in place that provide guidance with pesticides. These efforts have been ongoing and are changing to ensure the proper safety that is needed. Acts such as FIFRA and the RCRA provided a framework that has allowed the USDA and USEPA to work with producers and the environment and provide the guidelines needed. Where it lacks though is in the guidance for building the type of facility needed to control pesticide waste. Agency programs such as the Illinois Clean Sweep Program do help but does not occur frequent enough and does not appear to have the ability to handle the shear amount of pesticide that is out there.

Structure Considerations

Once the identification of the problem is and what the regulations are that are already in place, that’s where the actual building and design can take place. As stated before the sole purpose of a facility of this nature is to control escape of unwanted pesticide. A simple design was given which helps provide the information needed for the basic details of this structure.

Site Selection

Outside of understanding the current regulations and what the actual problem is, site selection is one of the most crucial aspects. This site should be sensitive to its surroundings and ultimately protect the environment much like the structure itself. Though SIU Farms does not seem to have flooding issues, this is a concern that must be addressed and protected against. Due to the nature of the bulk of chemicals being in small containers at the farms, it is left up to the chemical labels on how to properly store. This site however should be allow for the accommodation for both small and large containers and adequately, as previously mentioned, protect from any potential escape.

Chemicals and General Storage Precautions

Chemical labels do provide information on storage and disposal. It is important to read over these pesticides and understand what is on hand. It is important to have good organizational skills and keep things separated by pesticide type. The label itself is a legal contract and by following what it says helps ensure that no laws will be broken and that all will be done in the proper fashion. It is key not only for the environment but also the user's safety to understand the precautions associated with pesticides to help give guidance in developing a storage and disposal facility.

Mixing/Loading Pad

One of the key components to the goal of this type of structure is the area to mix, load and dispose pesticides and their waste. Without this part of the system, controlling pesticide contamination would be impossible. This pad acts as the barrier to contain any spills. It should be large enough to fit the largest booms and still provide at least 5 feet of space on each end. In the case of a spill, it was mentioned that this area is the protecting area and should be able to contain 110-125% of the largest container within the area. Specifics were provided, but it is concluded that the final design should meet specific needs at SIU.

Federal laws and regulations, as well as those provided by our state, can only do so much to assist in the proper handling and disposal of pesticide waste. The difficulty of implementing regulatory measures for the proper disposal of waste pesticide materials has resulted in certain illegal disposal practices such as rinsing spray tanks on open lots without providing containment, improper disposal of the rinsate solutions, dumping excess spray solutions and tank rinsings along fence rows, and discharging pesticide-contaminated waste-waters into ditches and streams (Schmidt et al., 1987). The challenge is to provide an answer on what type of structure that works in all circumstances, which will be nearly impossible to accomplish. It is pivotal to the future of not only the agriculture industry but also to our surrounding environment. The idea of facilities with the sole purpose of collecting our unused pesticide waste and storing agrichemicals is great and has worked for many years. It has reduced contamination issues but a federally regulated structure is needed so uniformity can be attained.

Recommendations

Further research needs to be conducted to deliver a solution that can provide a general set of standards that producers, farm service agencies, and research groups alike can all follow and abide by. Pesticide application is a crucial portion for much of research and production agriculture practices. It has been essential for the management of many pest problems seen throughout the world and in Southern Illinois especially.

It is recommended that continued research be done in the following areas: the redesign of pesticide application equipment, the development of a universal training system that would be functional throughout interstate travel, the enforcement of federal and state laws, and the design and implication of a general structure for both storage and disposal. Through the examination of similar structures used at other education institutions will the proper ideas that best fit our needs and potentially help create a universal structure for all research farms. Pesticides provide the greatest advantage for producers and researchers to be successful in the field and chemical application will continue to be used.

Because of its location, Southern Illinois University Farms is in a crucial area to build such a structure and because of the age of current structures, change is needed. Instead of just storing pesticide waste in one spot, chemical in another, and filling and mixing tanks in other areas, the recommendation for one structure to do it all makes sense. Due to the multitude of locations being sprayed, it would best serve the farms to seek a location easily attainable from all points of the farm, away from any wells but could have access to non-potable water. This structure should contain 4 cone shaped bulk stainless steel tanks to collect rinsate, rainwater, and any spills. Along the same lines, daily rinsing should be conducted and all vehicles used in pesticide application should be sprayed down at this facility.

The other containment structures that should be analyzed thoroughly is a concrete berm around the mixing pad and collection tanks and also a sump pump system, with a back-up sump, that can handle continued use. In the event of a leak or spill, the proper design of a containment berm should hold that 110-125% of the largest container. To ensure all is done to fit the farms current needs and future potential changes, thorough examination of other structures is needed.

In the end it is up to the product users to ensure the proper steps are taken for the safe handling of chemicals. The number one goal of researchers and producers, and the people involved in the usage of pesticides, is to provide adequate stewardship of our land. It is up to the proper handling of these pesticides to ensure the environment in which agriculturalists work is around and usable for years to come.

Overall, it is through the proper research, trials, and implications of laws and infrastructure that will allow for a brighter and safer future. The many pesticides used have a place and allow for not only the management of pest problems but also provides an opportunity to thoroughly examine deeper problems and advancements. Proper handling, storage, mixing, and disposal are the keys to safeguarding both the health of the environment and future generations.

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APPENDICES

Appendix I

Mixing and Loading Pad Specifications

(Sumner and Bader, 2009)

1. **Surface Slopes –** 2 percent minimum slope to facilitate washing.
2. **Pad Thickness –** 6 inches with reinforcement steel at 12-inch centers in both directions.
3. **Rinsate Storage –** Separate storage tanks for each chemical applied. Cross-linked polyethylene or fiberglass tanks of 300 to 600 gallon volumes are a good selection. All rinsate storage tanks should be mounted 3-5 inches above the concrete floor for location of tank leaks. Fiberglass, stainless, glass- lined or epoxy-lined tanks are normally used for liquid fertilizer.
4. **Sumps –** Sumps should be located near the rinsate storage tanks and be a minimum size of 2 feet by 2 feet by 0.5 feet, 2 feet in diameter by 0.5 feet deep. It should be covered with steel grating.
5. **Curbing –** The mixing/loading pad trimmed by a 3- inch drive over curb. This minimizes chemical spillage and increases containment volume.
6. **Management –** Sprayer systems should be rinsed with the vehicle parked on the wash pad.
7. **Containment Volume** is computed by the following equation:

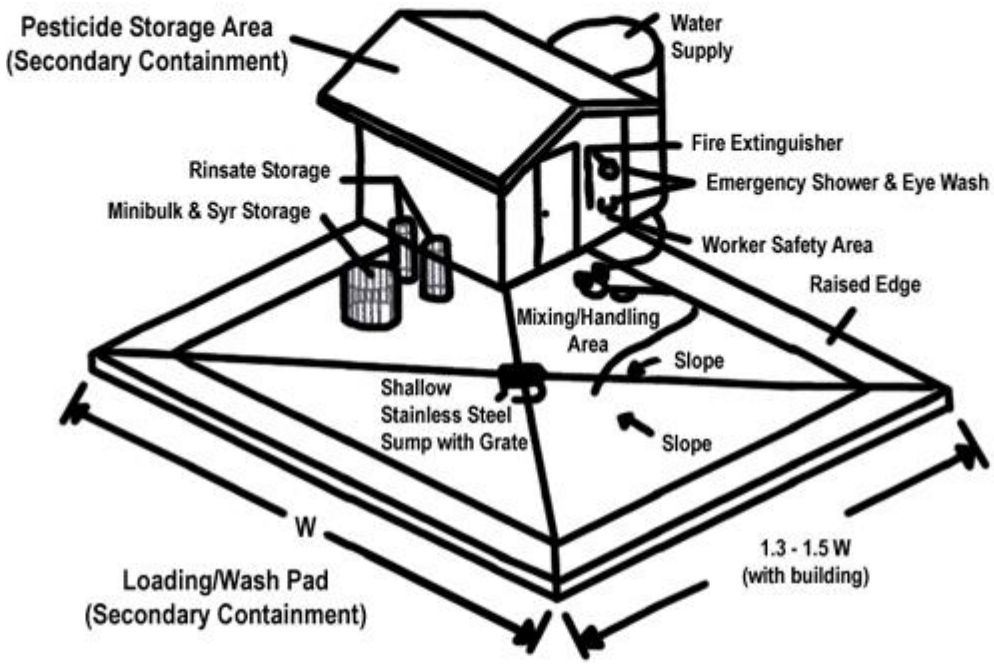
   $$NCV = \frac{(LTV-(GPF \times CVm) \times 1.25}{7.5}$$

   Where:
   NCV = Net Containment Section Volume, Cubic Feet.
   LTV = Largest Tank Volume, Gallons
   GPF = Gallons per Foot of Depth of Largest Tank
   CVD = Containment Volume Depth, Feet
8. **Containment Pad Area** is computed as follows:
   PA=NCV/CVD
   Where:
   PA = Containment Pad Area

Appendix II

Simple Pesticide Storage Area and Mixing/Loading Pad

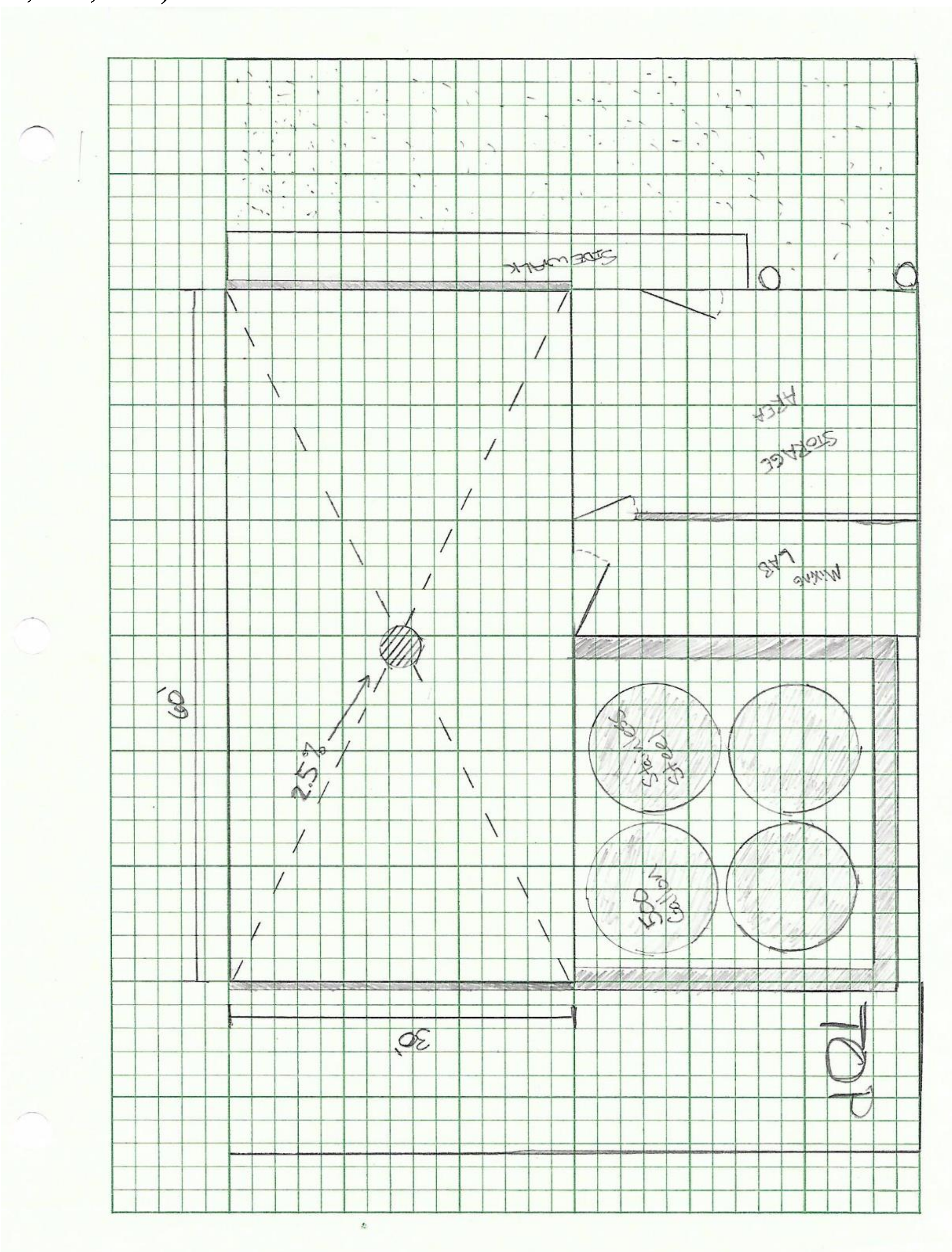
(Sumner and Bader, 2009)



Appendix III

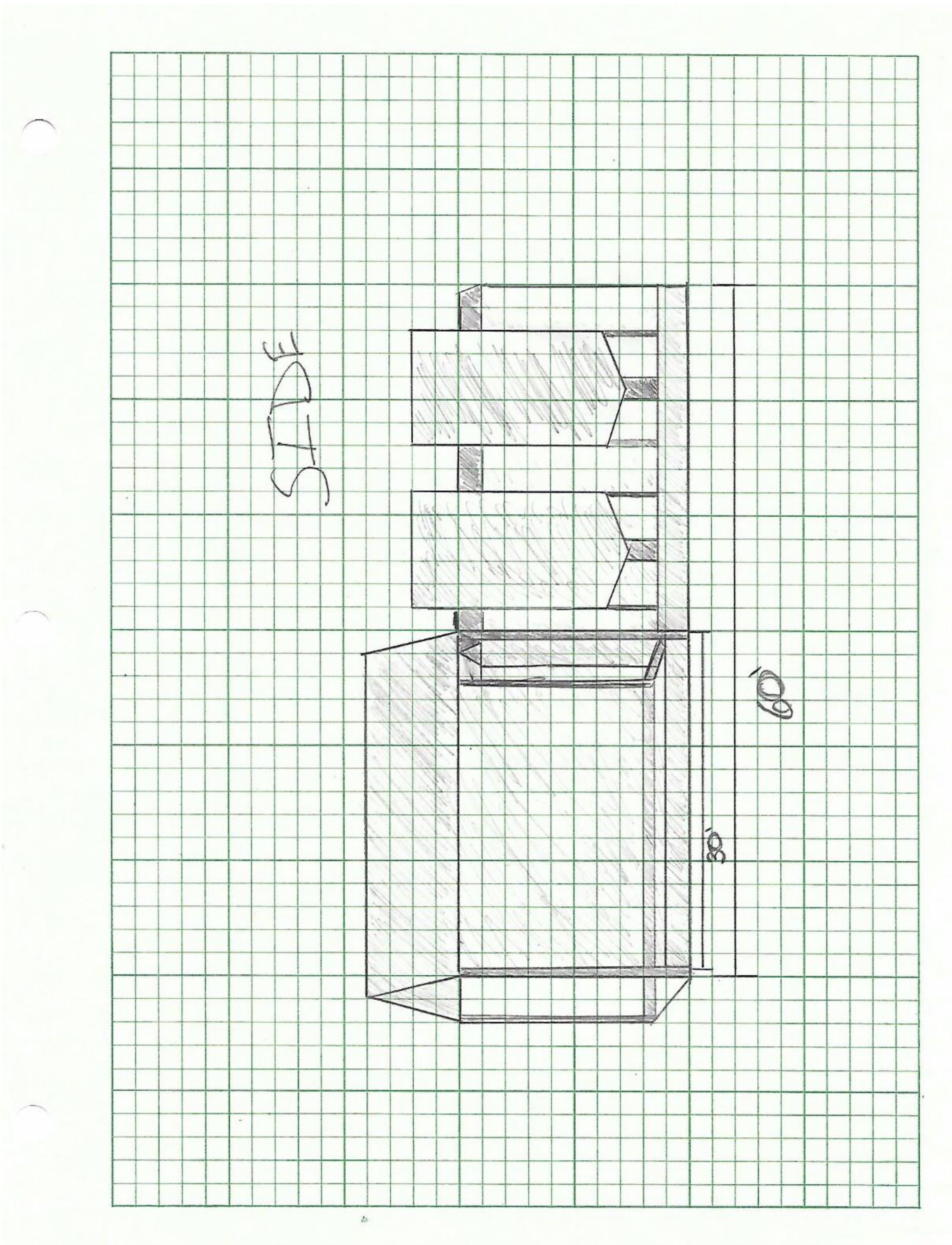
Design for SIU Farms Pesticide Storage and Mixing/Loading Pad top view.

(Ballard, T.B., 2016)



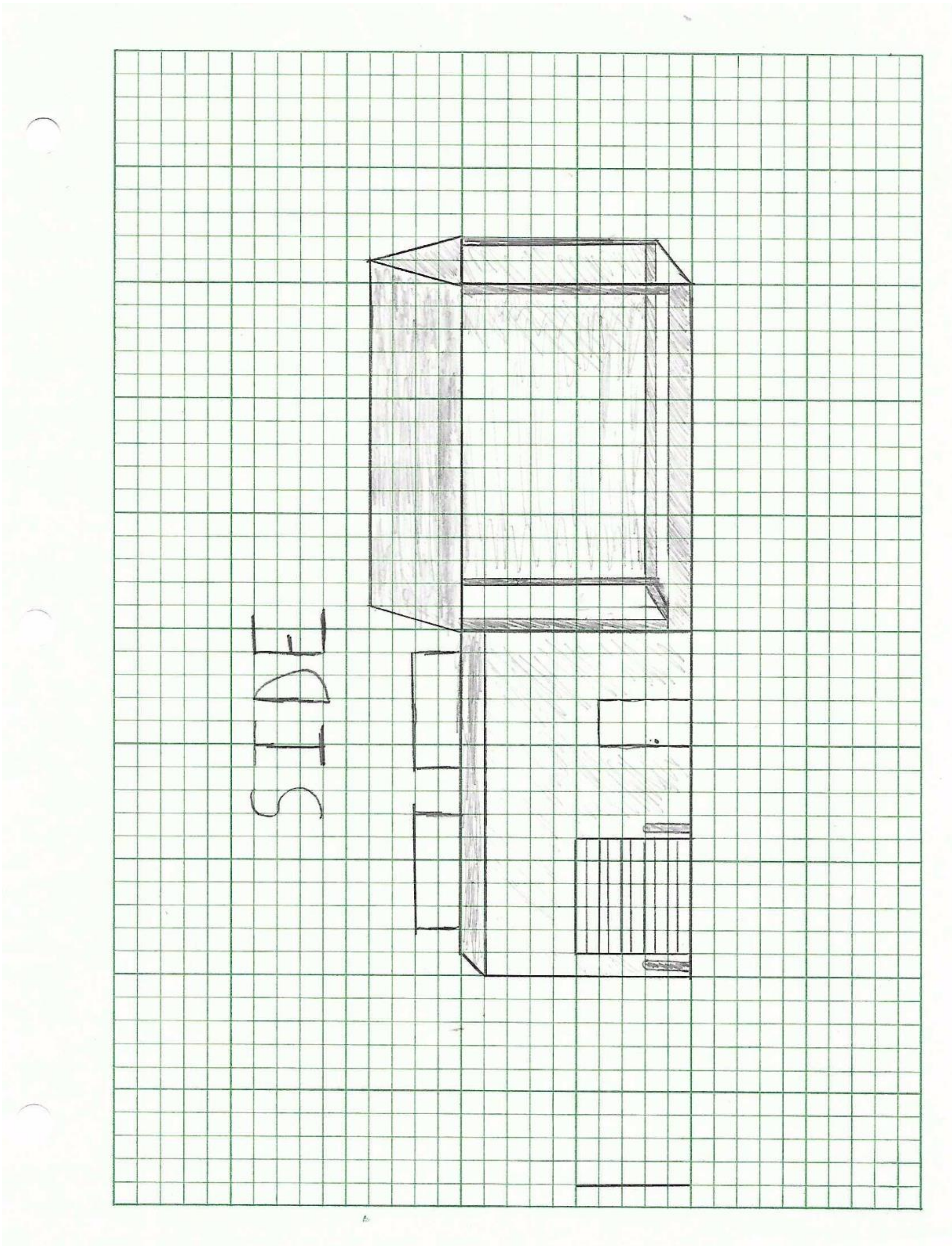
Appendix IV

Side view of rinsate storage area.



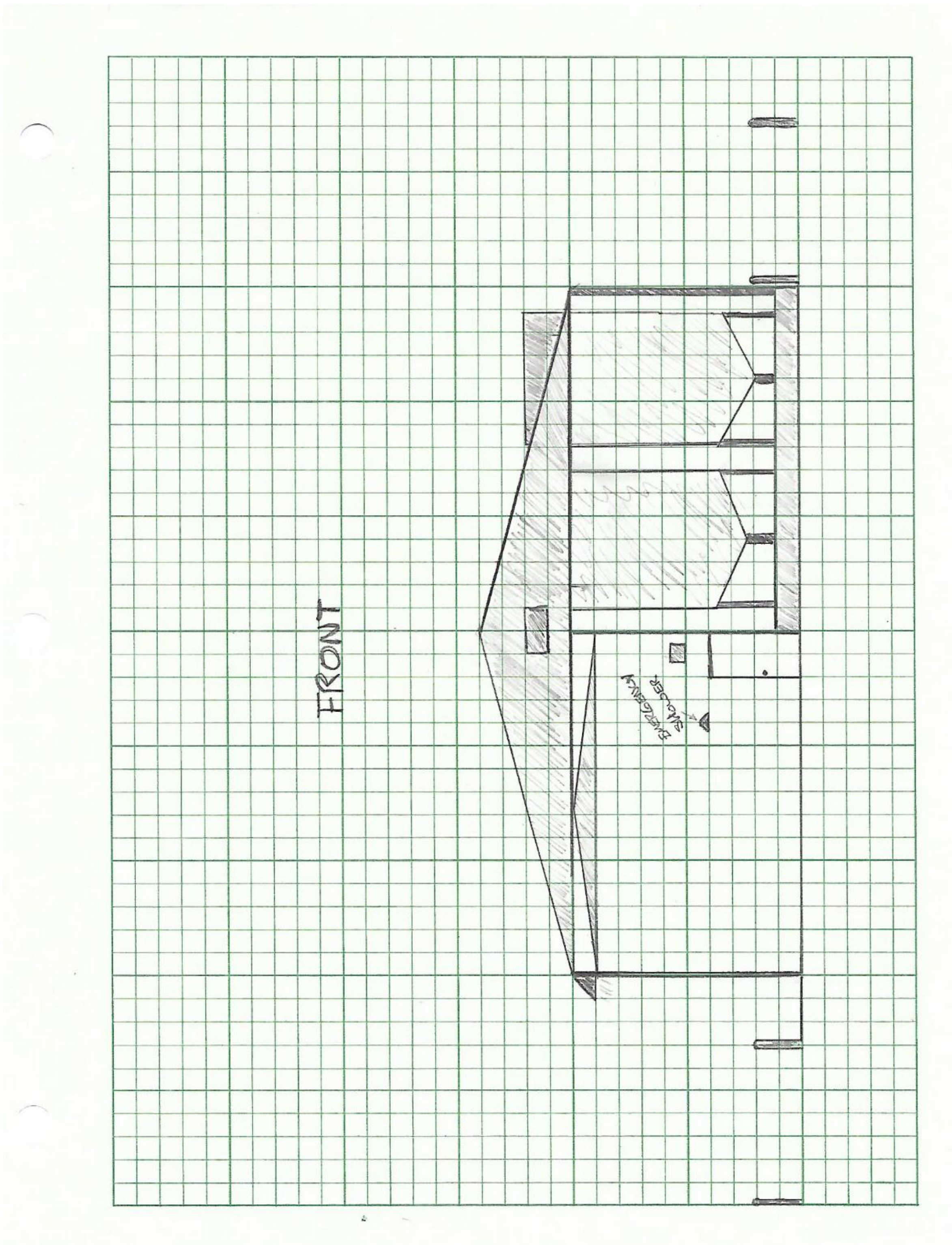
Appendix V

Storage side view of Pesticide Storage Structure and Mixing/Loading Pad.



Appendix VI

Front view of Pesticide Storage Struture and Mixing/Loading Pad.



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