

## **COVER PAGE**

Title of Design:

**Providing Secondary Containment for Mobile Refuelers**

Design Challenge addressed:

**Airport Environmental Interactions: Improving Methods for Containment and Cleanup of Fuel Spills**

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**FAA Design Competition for Universities: 2012-2013**  
*Providing Secondary Containment for Mobile Refuelers*



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## Executive Summary

The goal of this team was to design a method of secondary containment of fuel in mobile refueler parking areas. Six separate designs were created based on a proposed apron for Lee's Summit Municipal Airport (LXT) in Lee's Summit, MO. A case study was performed on this proposed apron to provide comparisons between the designs. Though the design process was created to address the needs of LXT specifically, the methods examined could be applied to airports of all sizes nationwide.

Another goal of the research was to analyze the regulations currently in place to prevent and treat fuel spills at airports. After becoming familiar with these regulations, it became apparent that a small or moderate sized airport could be severely affected by the cost of mitigation from a spill. The cost of having preventative measures in place is much less than the potential cost of excavating and transporting contaminated soil or remediating contaminated water sources.

Different methods of fuel containment and treatment were considered. The designs included retention ponds, oil-water separators, and dikes/berms and different combinations of each. For each design, the required quantities/materials were tabulated, and a final cost was determined.

After performing a cost analysis, it was determined that the best method of secondary containment for small to moderate sized airports was a dike/berm perimeter featuring a gate valve. The design requires the refueling area to be surrounded by dikes on three sides with the side open to the apron protected by a 6" berm. On the far wall, a gate valve is included that be opened after a spill event. The total estimate cost of the design for a sample airport, LXT, was \$39,622.60. The design satisfies the FAA's point of emphasis including practicality, economic feasibility, and regulatory compliance.



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## 1. Problem Statement and Background

The primary objective of this study was to address current issues in airport environmental interactions described specifically by the FAA. The specific topic addressed involved improving methods for containment and cleanup of airport fuel spills. The Environmental Protection Agency (EPA) promotes many regulations that are currently in place for the fuel handling within airport property. One of the most controversial standards currently in place regards the level of secondary containment present for mobile refuelers operating within airports. Primary containment is considered to be the tank of the mobile refueler. The fuel is contained by a device that, if functioning properly, will not allow fuel to exit the tank and cause contamination of groundwater. If the primary containment device becomes nonfunctional, then secondary containment would catch the fuel and keep it from contaminating groundwater or at least minimize the contamination.

Regulatory amendments state that although it is necessary to provide a form of secondary containment for mobile refuelers operating at airports, it is not necessary to provide containment for the full volume of fuel it is carrying. The distinction of how much secondary containment that is necessary for mobile refuelers is determined by an estimation of what is likely to spill if an incident occurs. This means that if a mobile refueler spilled its entire load on an airfield pavement, there is likely inadequate containment available for the airport to efficiently contain and dispose of the fuel.

A fuel spill where adequate secondary containment is not available can have serious implications on an airport if it is not contained at the onset of the fuel spill. A fuel spill will cause areas of the airport to be closed off possibly causing delays in the airport's traffic. The

combustibility of the fuel results in extreme safety hazards for equipment or personnel within the vicinity. Fuel can seep into pavement, causing structural damage to the surface pavement, as well as contaminating the subbases and subgrade of the pavement structure. Most importantly, the fuel could contaminate airport runoff and cause severe damage to the environment resulting in massive cleanup costs for the airport.

Even though the chances of a voluminous fuel spill of this nature are relatively low, it is widely understood that the costs to cleanup an uncontained fuel spill greatly outweigh the costs required to provide complete secondary containment in the first place. Secondary containment techniques that can be used for this purpose can be summarized into three categories: oil water separators, barrier methods and spill diversion ponds. Each of these methods includes several specific systems that vary in cost and efficiency.

The primary purpose for this study was to use research and professional interactions to improve methods for containment and cleanup of fuel spills by producing, analyzing, and designing a variety of system alternatives that would provide effective secondary containment for the entire volume of fuel within mobile refuelers. Once the top alternatives were identified, computer design and analysis was used to make a conclusion on the most cost-efficient method of secondary containment developed in this study. Our study was based on a smaller airport due to the large cost of cleanup that follows a massive fuel spill. If a massive fuel spill occurs at a smaller airport, the funds needed for the containment and cleanup are harder to acquire due to the lower revenue for the smaller airport. If the same massive spill were to occur at a larger airport, the funds would be more readily available; therefore making the affects larger on the smaller airport.

## **2. Summary of Literature Review**

Current regulations in place to prevent and treat spill events as well as potential methods of secondary containment were heavily researched as part of the literature review. The research primarily follows EPA's SPCC guidelines (40 CFR 112).

### **2.1 Current Regulations for Fuel Spills**

The Spill Prevention, Control, and Countermeasure (SPCC) regulation (Environmental Protection Agency, 2009) defines a "non-transportation" facility as one that stores, processes, refines, uses or consumes oil without intending to move it from one location to another. Many regulations are currently in place to prevent and control fuel spills in non-transportation related facilities such as airports. The current regulations aim to prevent discharge of fuel into navigable waters of the United States as defined by the 1972 Clean Water Act (US Code of Federal Regulations, 1972), as well as provide guidelines for clean-up procedures should a spill occur. The regulations are enforced by the EPA and serve as federal law.

Prevention is the most important step in ensuring environmental safety and should be the main focus when handling fuel at airports. EPA enforces the SPCC regulation to prevent hazardous spills and reduce reliance on clean-up regulations (40 CFR 112). Federal Law mandates that each airport drafts its own SPCC based on the types of fuel storage tanks and refueling methods.

The SPCC regulation establishes inspection requirements for a variety of fuel storage containers. Containers covered by the SPCC primarily include above ground, below ground, and mobile refuelers. The primary test method for above ground containers and mobile refuelers is a visual inspection, whereas the primary test for underground containers is non-destructive

evaluation. In both cases, it is required that either the owner or a registered professional engineer inspect and approve the storage device. EPA recommends that the storage containers perform at industry standards, which are not directly defined by EPA. “Industry Standards” does not have a formal definition but usually refers to a series of industry inspections from one such as the Steel Tank Institute (2011). Once the industry inspections are approved, EPA must agree that the industry standards were used in “good engineering practice” (40 CFR 112).

Record keeping is also required under industry standards (40 CFR 112). Under Steel Tank Institute (2011) industry standards, each tank must be inspected monthly and annually, and the reports for each inspection checklist must be kept for 36 months. All certified inspection reports on the storage tank must be kept for the life of the tank. The reports are kept to be reviewed and referenced in case of failure or replacement.

In case of a fuel spill, EPA and FAA have guidelines in place to minimize damage to the surrounding environment. EPA first determines whether a spill is reportable or not by referencing the Oil Spill Prevention Act (40 CFR 112). If a discharge violates applicable water quality standards or causes sludge to be deposited beneath a surface of water, the spill must be reported or those at fault may be subject to fines or criminal prosecution in extreme cases. Any reportable spill must be immediately remediated.

Once a spill is reportable, EPA refers to the National Oil and Hazardous Substances Pollution Contingency Plan, or the National Contingency Plan for short (EPA, 1968). The National Contingency Plan (NCP) establishes a response team and states the responsibilities of federal on-scene coordinators. The plan also establishes a general pattern of response and gives on-scene coordinators the right to enforce appropriate orders to mitigate the effects of the spill.

The NCP applies more closely to large open water oil spills than it does to airport fuel leaks, but if a leak on airport property is bad enough that public welfare is at risk, then an on-scene coordinator will be dispatched and the NCP will be ordered.

FAA provides its own document for treatment of oil spills, the 403 Standard for Aircraft Fuel Servicing (NFPA 2012). The document states that the first response should be to immediately discontinue fuel service and call the local fire department. If a spill becomes severe enough, it may be necessary to inform the EPA or else face charges of failing to report a hazardous fuel spill. The NFPA 403 then gives instructions for shutting down traffic through the area and blocking the spill site off so that proper personnel can enter and handle the issue. The scope of the NFPA 403 applies more closely to airports than the NCP, but both may be used depending on the severity of the spill. The NCP is also very important when considering airports located near the water's edge of navigable waters of the United States.

While the current regulations do a good job of preventing and mitigating airport fuel spills, they do not adequately address some issues. Currently, there is no regulation in place requiring secondary containment on mobile refuelers (40 CFR 112). A secondary containment tank is defined as one that could hold the full volume of the primary containment should a leak or spill occur. Secondary containment is required, but the containment device could be surrounding the airport in the form of a dike rather than on the mobile refueler itself. Current provisions have plans for containing mobile refueling spills once they occur but have no regulations in place to prevent them. If a mobile refueler suffered a leak in its primary containment, then the fuel would leak directly to the surroundings and pose a major fire and health risk.

## **2.2 Methods of Secondary Containment**

There are many different methods and techniques used by airports for the secondary containment of fuel spills. Though load bearing is pavement's primary purpose, it is also the first barrier against percolation of fuel and should be viewed as initial secondary containment. For specific containment and treatment purposes, the SPCC has a list of recommended methods that can be applied to fuel services on airports. (40 CFR 112). The methods defined can be summarized into three different general categories: oil water separators, barrier methods and spill diversion ponds.

### **2.2.1 Fuel Resistant Pavement**

Pavement used in refueling areas must be resistant to fuel and impervious. In the event of a spill, pavement must be able to hold the entire volume of the spill before further methods of containment and treatment can be used. Concrete Paver, a type of concrete mix consisting of Portland cement with coarse and fine aggregate, is a very strong mix that is both impervious and fuel resistant. For airfield pavement, the Interlocking Concrete Pavement Institute prefers concrete paver over traditional hot mix asphalt and Portland cement concrete mixes due to its structural integrity and joint strength (McQueen et al, 2003). ICPI states that traditional PCC mixes are normally fuel resistant but the joint sealant can deteriorate, decreasing the pavement's strength. Concrete paver solves this issue by not requiring a joint sealant to maintain structural stability. In addition, ICPI has found no evidence suggesting that fuel can penetrate the pavement and collect in the subbase (McQueen et al, 2003).

### 2.2.2 Oil Water Separators

Another commonly used method of fuel spill containment involves the use of an oil water separator, also known as a runoff fuel separator system. This method involves placing a runoff fuel separator at the end of an airport pavement drainage system. The runoff fuel separator uses an enhanced gravity separator system to collect and contain oil from in-flowing water, resulting in an effluent of water with a minimal level of hydrocarbons remaining in it (Mohr, Coulson & Zarraonandia, 2001) Usually the system is setup so that catch basins capture the flow path of any part of the apron that can be subjected to fuel spills (such as the area around fuel tanks and where fuel trucks are filled). The influent of the catch basins flows through underground drains leading to the fuel separator (EPA, 2005) As long as the gradient of the apron is established well enough to ensure full drainage into the catch basins and the separator is designed to handle the expected flow rate, this method of spill protection is one of the most effective spill control measures that can be taken. The fuel spill will be in contact with nothing but pavement and the drains beneath the surface, and the fuel will be separated from the effluent and safely contained within the separator.

Although the oil water separator is one of the most effective methods of containment, it also comes at the steepest price. If this system is applied to an airport, the price will vary immensely depending on how the apron's drainage system is currently set up. Heavy construction cost experts estimate that the cost of the separator alone (excluding excavation and backfill) ranges from \$20,800 (0.5 cf/s) to \$104,500 (22 cf/s), depending on the expected flow rate (R. S. Means 2009). If the apron already has catch basins and an underground drainage system, the price of installing the separator to the end of the drains will be significantly less than the cost it would take to apply this method to an apron with no underground drainage system. In

order to apply this method to an apron with no underground drainage, crews would be required to demolish the existing pavement, install pipes and catch basins, then re-grade and repave the apron, leaving an enormous bill for the airport owner.

### **2.2.3 Barrier Methods**

A more cost efficient means of fuel spill containment involves the use of barriers. Containment of fuels spills using barriers consists of strategically placing physical obstructions such as dikes and berms to contain the full volume of a spill in a strategic area in order to prevent any contact of the spill with groundwater runoff (EPA, 2005). Dikes are permanently constructed concrete walls 0.5 to 6 feet tall that are commonly used to surround fuel tanks as a method of secondary containment (Occupational Safety and Health Administration, 1994). EPA mandates that these dikes must be of the proper length, width and height to account for 110% of the full volume of tank(s) it surrounds (EPA, 2005). The cost to construct a 1.5 foot dike is relatively low, about \$3.94 per linear foot (R.S. Means, 2009). When compared to the product and installation costs of an oil water separator, dikes are a cost efficient alternative for secondary containment. The main drawback is that dikes do not allow for aircrafts or mobile fuelers to cross them, meaning they are only effective when used to surround stationary fuel pumps.

An effective alternative for dikes that allows for mobility is a berm. Experts estimate berm prices to be very low at \$2.86 per linear foot (R.S. Means, 2009). A berm is a small, heightened asphalt mound (4 to 6 inches) that is most effective when placed in a perimeter around an area susceptible to spills from mobile fuelers. The berm's rounded top and small height enables fuel trucks to easily pass over the top of it. If the perimeter is designed properly,

berms are able to prevent a spill from a mobile fueler from flowing out onto the rest of the pavement (EPA, 2005).

Both dikes and berms are very efficient for containing fuel spills. However both structures only prevent fuel from leaving the airfield pavement, they do not account for the physical removal of it. EPA defines two distinct methods in which the fuel can be drained out of its designed entrapment: passive and active control. Passive control is defined as the methods used to contain the entire amount of an oil spill with no human involvement necessary (EPA, 2005). A commonly used method of passive control is having a catch basin at the lowest graded area of the perimeter that directs straight into a runoff fuel separator such as the one discussed before. This combination of a dike/berm and runoff fuel separator is very effective, but would prove costly when compared to an exclusively dike/berm system

A more cost-efficient method for disposing of the trapped fuel spill would be active control. Active control refers to containment methods for which human interaction is necessary to contain and dispose of an oil spill in its entirety. Some examples of active control involve using gate valves or drain covers to prevent the outflow of contaminants. An area contained by a dike or a berm still requires a means of draining non-pollutant water from precipitation or other sources. A gate valve is a device that goes through a dike or berm and normally allows the flow of fluids through it. In the case of a fuel spill however, the gate valve has a mechanism that will seal off the flow and contain the spill inside the perimeter (EPA, 2005). The gate valve contains the entire volume of a fuel spill until it can be safely disposed of by clean-up crews. The dike/berm/gate valve system is a much cheaper alternative to using a drainage system/fuel separator combination. Ideally, EPA recommends closing the gate valve before any instance that could likely result in a fuel spill take place, such as refilling the fuel tanks or filling the mobile

refueler from the fuel tanks. If the gate valve is neglected and is not activated until after the spill has occurred, a portion the fuel will leak out and be uncontrolled.

If a drainage system is in place and there is no fuel separator at the end of the system, using a drain cover is a very cost-effective solution to preventing the fuel from entering the drainage system. If the drain cover works as designed, it will contain the entire volume of the fuel spill until the fuel can be removed by clean-up crews. A drain cover is exactly what it sounds like, a seal-tight cover to be placed on the top of a catch basin to seal off the drainage system from contaminants (EPA, 2005). Use of a drain cover is very similar to the gate valve; its effectiveness depends entirely on the personnel in charge of it. EPA recommends, as with the gate valve, that it is ideal if the drain is covered on every occasion that a fuel spill is likely to occur. However if this practice is not always followed, the cover will be placed after the fuel spill and fuel will likely spill into the drainage system.

When using a gate valve or drain cover, it is very important to quickly remove the fuel. These containment measures are only effective if the spill is properly disposed within hours of the spill event. According to the AAPTP, ponding fuel can cause deterioration to the pavement and contaminate the soil beneath it. To counteract this, the airport must have a reliable spill response team on hand to quickly dispose of the oil and decontaminate the area.

#### **2.2.4 Spill Diversion Ponds**

The most cost-effective and least effective method of secondary containment is the use of spill diversion ponds. Spill diversion ponds are nearby natural or man-made ponds designed to directly intake airfield runoff. The purpose of this system is to prevent the influx of contaminants from the airfield from entering surface water bodies by permanently containing the

contaminants in a pond. In order for a pond to be used for this purpose, an EPA inspector must approve of the conditions. It must be proven that the system can withhold the design capability such that minimal seepage of contaminants occurs in an area subject to frequent flooding (EPA, 2005). Despite the regulations, this is one of the least practical means of secondary containment because it is the intentional contamination of an uncontrolled substance of water. The soils and buried earth surrounding the pond will be subjected to the fuel. In a case of a flood occurring, the contaminants in the pond will lose all control and flow freely through the ecosystem.

### **3. Problem Solving Approach**

The primary focus of this study was to discover and compare cost-efficient means of complete secondary containment that can be utilized by airports of all sizes. During this study, several innovative techniques were designed that incorporate a variety of different containment components. The approach analyzes a case study, establishes a preliminary design base model based on airport characteristics, and applies the base model requirements to establish six thorough designs that satisfy the fuel containment needs of the chosen airport.

#### **3.1 Description of Case Study**

Large airports with heavier environmental concerns and budgets would be very flexible in choosing their preferred method of secondary containment. However, many small to mid-sized airports around the nation operate on a tight budget, meaning that the primary obstacle to the application of secondary containment is the costs that would be associated with it. Complete secondary containment for mobile refuelers is often overlooked as a financial priority because it is not required by federal regulations. Although it is not a necessity, small airports would benefit

by having these systems in place because a spill without containment could financially overwhelm the airport. In order to determine which methods would provide refueler containment to small airports for the cheapest price, the case study was organized and performed on a small airport.

Many different small airports were compared to determine the most effective location for the case study. The one which was decided upon was Lee's Summit Municipal Airport (LXT) in Jackson County, Missouri. LXT caters to an average of 138 operations per day, two-thirds of which are general aviation. As can be seen in Figure 3.1, LXT has a simple primary/crosswind runway system with two Class I runways that are approximately 4000' x 75' each. As a relatively small airport, it has to be very cost efficient with its design because it will have a smaller budget than large international airports. What sets LXT apart from other small airports is the heavy influence the location has on its surrounding environment. As seen in Figure 3.2, a fuel spill at LXT could have profound effects on the environment as the runoff from the airport leads directly into Unity Lake, a major water supply for the local population.



Figure 3.1. Overview of LXT



Figure 3.2. Runoff of LXT into Unity Lake

The case study at LXT specifically involved an actual proposed fuel apron that will be designed and built within the next 5 years according to the manager of LXT, John Ohrazda. Figure 3.3 displays a close-up of the preliminary design for the proposed fuel apron, which includes a 10,000 foot apron with fuel tanks and a maintenance building attached to it. Mr. Ohrazda stated his interest in the addition of a parking area for his mobile refuelers to the proposed apron. LXT currently has two refuelers, a 1,200 and 2,500 gallon truck, both 28 feet long. At night these trucks park in the grass alongside the main hanger. At the current location, the trucks pose minimal risk but would be better off in a permanent location that incorporates secondary containment.

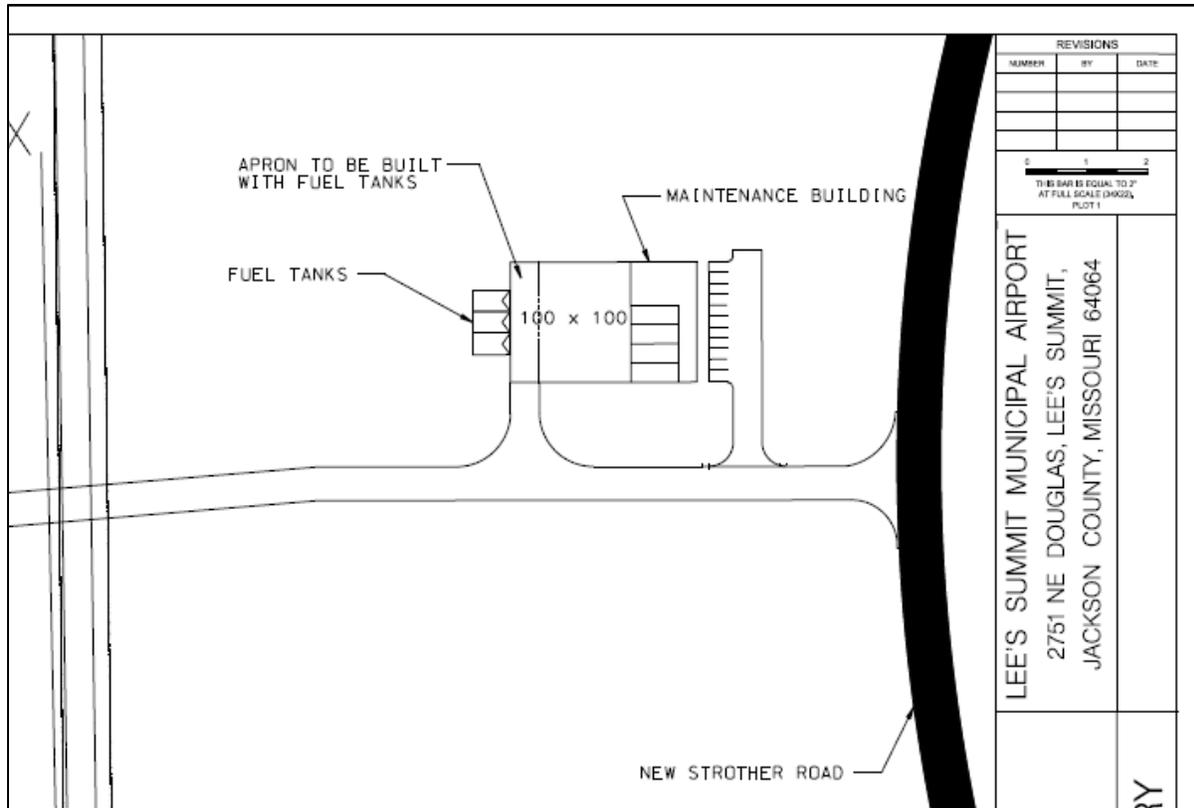


Figure 3.3. Preliminary Design Plans for Proposed Apron at Lee’s Summit Municipal Airport (Courtesy of Crawford, Murphy and Tilly, Inc.)

### 3.2 Design of Base Model

In order to make an accurate comparison between the alternatives, it was necessary to design the refueler parking pad to be used as the base model. The fundamental design characteristics were established based on the airport layout along with the size requirements necessary to handle both the size of the trucks and containment for spills.

#### 3.2.1 Refueler Parking Location Assessment

The location of the mobile refueler parking area is unique to each airport, and this location depends on land characteristics of the airport’s property. LXT sits less than a mile from

three lakes, so a spill could create a number of potential Clean Water Act (CFR 1972) violations. The proposed project location is indicated as a circle on the topographic map in Figure 3.4. To avoid pollutant flow as much as possible, the parking area was located on the west lining of the apron so that any flow from the parking lot would be directed away from the apron. As discussed in the literature review, the concrete used to pave this area will be the fuel-resistant “concrete paver”.

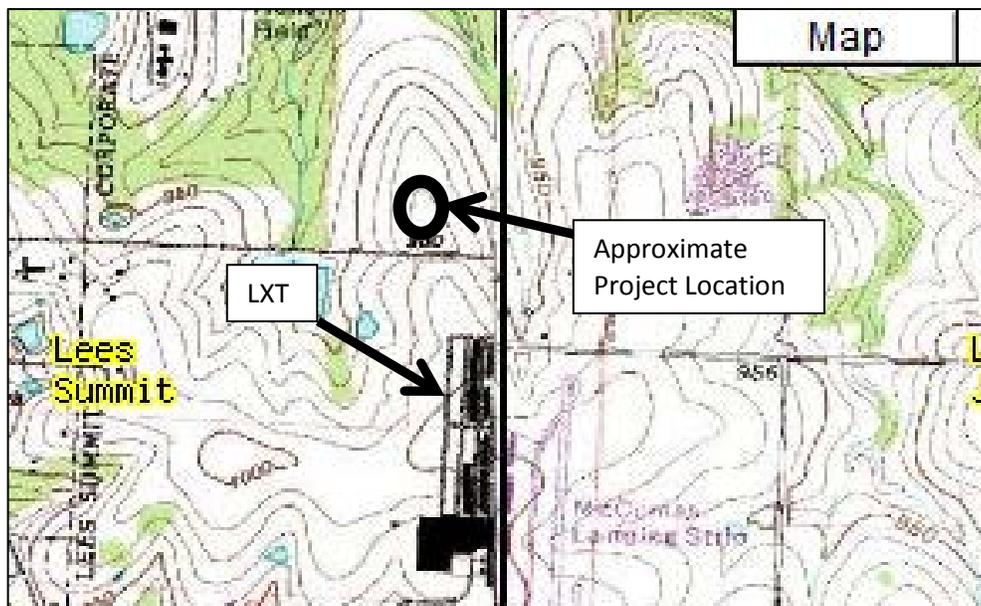


Figure 3.4. United States Geological Survey Topographic Map of Lee's Summit Municipal Airport

### 3.2.2 Refueler Parking Size Assessment

The parking area was designed at appropriate dimensions that accounted for current inventory and potential growth. The area of the parking lot was designed as 36'x40' area- based on the dimensions of the refuelers currently in operation. The 36' length of the pavement is enough to accommodate the 28' length of the trucks, while the 40' width of the pavement

provides adequate space for a future third vehicle. Based on LXT's size, it is unlikely that the airport would require more than three refuelers in the future.

### **3.2.3 Spill Volume Assessment**

According to the SPCC, secondary containment in refueler parking areas must be able to contain 110% of the truck's fuel capacity plus the maximum 24 hour rain event over a 25 year period (40 CFR 110). Designing for the determined surface area of 1440 ft<sup>2</sup> (36' x 40'), 110% of a 2500 gallon spill would occupy 354 ft<sup>3</sup> within the system. This volume of spill would cause a 2.95 inch spill height within the system. Additionally, the maximum 24 hour rain event over the last 25 years in Lee's Summit was observed as 2.3 inches (Weather Warehouse 2012). Therefore, the containment system must hold 5.25 inches of fuel plus rain if both extremes occurred at exactly the same time. Under these circumstances, a suitable design berm height would be 6 inches. The 6 inch design would satisfy the maximum and simultaneous rain/fuel event without posing a clearance issue for the refuelers as they move in and out of the fueling area.

### **3.3 Analysis of Alternatives**

Once the parking area location and size was determined, it was necessary to apply each of the potential fuel containment solutions that were proposed and analyzed. Unlike traditional containment systems, these designs incorporate a number of individual containment components, forming a unique system based on the airport's needs. The drawings and cost estimates of each alternative can be found in the description of technical aspects.

Alternative 1 represents the control or baseline as it is the current condition without any new pavement. While it is the lowest cost alternative, the option does not address the need for secondary containment for mobile refuelers.

Alternative 2 incorporates a surrounding dike as well as a 6" asphalt berm on the truck entry side. The design also includes a gate valve to remove pooling rainwater. The pavement is graded so that all liquids flow to the corner for which the gate valve is installed. This alternative is very effective at containing the entirety of a fuel spill should one occur. The 36'x40' parking area with 6" of dike and berm coverage could hold 720 ft<sup>3</sup> before overflowing, which was determined to be enough containment in the preliminary designs. One major drawback with this alternative is that fuel trucks may experience difficulty clearing the 6" berm during inclement weather.

Alternative 3 involves a grated inlet and catch basin centered in the parking area that leads fluids through a 12" reinforced concrete pipe to a nearby excavated retention pond. The pavement is graded in a way such that all liquids move towards the inlet. The retention pond would require a large amount of earthen material to be moved, and there are other issues surrounding the placement of the pond. While relatively cheap, the single drain is subject to being blocked.

Alternative 4 uses a trenchdrain instead of an inlet and drain. The trenchdrain would line the entire width of the truck-entry side of the parking area, and all pavements would be graded such that any liquids would flow to the entry side. The trenchdrain leads the fluids to a reinforced concrete pipe which directs the fluids into a retention pond described in Alternative 3. This proposal is efficient since pavement would only be graded in one direction without a berm. Trucks could get in and out of the parking area with ease.

Alternative 5 uses the same inlet and drain system as Alternative 3, but drains into an oil water separator rather than a retention pond. While more expensive, the oil water separator

releases water back into the environment after removing the contaminant. The separator would have to be decontaminated in the event of a spill.

Alternative 6 employs the trenchdrain discussed in Alternative 4 in combination with an oil water separator. This is the most expensive but the most effective of the spill countermeasures suggested.

Each potential method was overlaid onto the designed base model of the proposed parking area using AutoCAD, and the quantities of each item used were tabulated. The quantities were then processed alongside their respective unit price cost estimates from the RS Means guide (Means, 2010). The total cost required to apply each alternative to the apron was estimated using spreadsheets. The detailed methodology used to determine the cost estimations are discussed in the Description of Technical Aspects section of this report.

Table 3.1 summarizes the results of the analyses with a brief description and the expected cost of each fuel containment method. Each listed method is fully capable of providing complete secondary containment; therefore the primary objective of the comparison was to choose the method which proves to be the most cost efficient. The table shows that as expected, the control method (Alternative 1) is far more cost efficient than the other five methods. Of the five innovative methods developed by this study it can be seen that Alternative 2 was the most cost effective, therefore Alternative 2 was chosen as the best secondary containment design option.

Table 3.1. Cost Summary of Fuel Containment Alternatives

Alt.	Alternative	Cost
1	No Pavement - Regrade and Excavate Retention Pond	\$2,600.76
<b>2</b>	<b>Construct Pavement with Dikes, Berms and a Gate Valve</b>	<b>\$39,622.60</b>
3	Construct Pavement with Inlet and Drain into Excavated Retention Pond	\$43,513.26
4	Construct Pavement with Trenchdrain, Drain to Excavated Retention Pond	\$45,901.86
5	Construct Pavement with Inlet and Drain into Oil Water Separator	\$60,540.00
6	Construct Pavement with Trenchdrain and Drain into Oil Water Separator	\$62,851.10

## 4. Safety Risk Assessment

### 4.1. Description of System

The secondary containment area is designed to be a safe zone for fuel spills. The area is 36' x 40' providing room for a maximum of 3 mobile refuelers to be parked at one time period. Mobile refuelers will be driving over a 3" berm and parking in the area bounded by 18" dikes any time they are not in use. In the event of a fuel spill or leak the fuel will be allowed to pool in the area. This pavement used for the containment area will be made up of 'Concrete Paver' material which is fuel resistant meaning the fuel will pool until cleaned up. There is also a gate valve to be used for emergency disposal of fuel that has collected in the containment area. The driving condition of pavements can be of concern if fuel spills are not cleaned up properly. Snow, ice, and rain can also affect the control of vehicles driving on the secondary containment area.

## **4.2. Identification of Hazards**

Hazards within this system includes failure of the equipment that are used for the system. The area is designed to allow for fuel spills from the parked refuelers at any time, however this means that the system could contain fuel at any time. The closed gate valve may fail as well, allowing fuel to spill out into the grass outside the area. Human error becomes a hazard mainly in the operation of the equipment as well as the cleanup of fuel spills. Operation of the mobile refuelers in the area could pose as a hazard when it comes to damaging the containment area's boundaries as in the dike or berm due to lack of training, inattentive driving, or a variety of other factors. Operation could also be affected by environmental hazards such as snow, ice, or rain creating a slick pavement posing a threat to the handling of equipment safely in the area. Finally, the hazards of improper clean up could be in the form of leaving leftover fuel from the spill or fuel spill outside containment area with improper use of gate valve

## **4.3. Analysis of Risks**

The most severe risk associated with this system is the event that a fuel spill ignites. Given the event that a fuel spill occurs, the primary hazard associated with this system is that the fuel will pond directly on the parking area until it is detected and can be cleaned up. The ponded fuel could ignite and cause severe damage to the system, nearby refuelers, or human life.

There is a risk of loss of control of mobile refueling trucks resulting in collisions between the trucks and the system or with other trucks parked in the area. The damage to the system could include damaging the gate valve, berm, or dike boundaries.

Other risks to consider would be the fuel containment area overflowing over the boundaries of the secondary-containment area. This can be discarded however given the fact that the area is designed to adequately hold the maximum amount of fuel in the mobile refuelers.

#### **4.4. Assessment of Risks**

Fuel ignition could damage the system, destroy the vehicles and most importantly cause personal harm or death. If a large fuel spill does occur, the damages incurred from a fuel spill ignition would be classified as catastrophic. Although it is very severe, this event is extremely remote to occur because there should be absolutely no activity in or around the proposed parking area except for the immediate cleanup of the spill by trained personnel. Based on the Predictive Risk Matrix (PRM) from AC 150/5200-37 (FAA, year), fuel spill ignition is considered a high risk event.

There is risk of collision between trucks and different parts of the system due to many of the hazards aforementioned. Neither a truck to dike or truck to truck collision should cause any harm to the driver because the trucks would be driven at extremely low speeds, meaning only very low impact collisions would occur. A truck to dike collision would have no safety effect because the dikes only have a height of 18 inches, meaning the absolute worst case scenario would simply be a flat tire. There is also a slight possibility that a truck may overturn because of impact with the dike. This could cause severe damage to the equipment and/or the driver. The probability of this event occurring is low because trucks will be moving forward in most cases and will more likely roll over the dike and out of the system than overturn from the back end over top. Trucks would have to slide or be collided into to overturn on its side with impact of the dike. . The combination of these two factors according to the PRM would make this event a low

risk situation. A truck to truck collision would be highly improbable because the width of the parking area provides very sizeable room for two trucks to park. The event has an effect of minor severity because minor damages could occur to one or both trucks or their fuel tanks. The PRM categorizes these events as low to medium risk.

#### **4.5. Treatment of Risks**

When analyzing the risks caused by fuel spills, the best mitigation techniques involve cleaning the fuel spills as soon as possible. This should be done using clean up methods already in place for LXT. In the event of a fuel spill, crews should attempt to clean the spill without moving the refuelers from the area, as to not track the fuel out of the containment area. If not possible, the area is large enough to relocate refuelers for the time being, so crews can fully clean any fuel pooled in the area.

Proper training and preparation of drivers will be key to mitigating risks involved with inclement weather, as well as normal conditions in the proposed system. Preparation of driver's is key to avoiding risks involving incursions as well as keeping the system in order. Drivers should understand the proper routes and procedures of parking mobile refuelers in the containment area. This will involve signage throughout the airfield and in front of the secondary containment area. Striping of the area for parking and driving lanes will also keep the system in order and prevent incursions before they can occur. Advising drivers of harsh conditions is also necessary to avoid any incursions when leaving or entering the containment area. The vehicles themselves can also be prepped with chains for traction during icy conditions. Measures should always be taken to reduce the effect of snow and ice on the pavement as well by salting the roads. The risks involved with improper maintenance of the system can be fixed by inspection of

the berms and pavement for cracking or damage every few weeks. If a problem arises with the pavement or berm, action should be taken to improve the condition of the system through chip sealing or overlay.

## **5. Description of Technical Aspects**

Performing an accurate assessment of the cost estimations on each different estimate required a many step process used commonly in engineer consulting firms. The order of tasks for the process described is as follows:

- Create cost estimation spreadsheet
- Determine every item to be used in construction for each alternative
- Find unit price estimations for each item
- Create design drawings of each alternative in AutoCAD
- Perform a quantity analysis for the items in each drawing
- Tabulate quantities in cost estimation spreadsheets

### **5.1 Construction Items and Unit Price Assessment**

First crude sketches were drawn of the approximate designs and a list of the total combined construction items necessary for all 6 designs were evaluated. Each construction item was determined, and the unit prices for every single item was found using RS Means (R. S. Means 2009). The detailed list of construction items along with their related unit prices and listed page numbers in RS Means can be found in Table 5.1.

Table 5.1. Overview of Construction Items and Unit Prices

Lee's Summit Municipal Airport Proposed Fuel Apron - Secondary Containment <b>Cost Estimate Spreadsheet</b>						
No.	Item	Quantity	Unit Type	Unit Price	Cost	RS* Page
1	Grading	-	SY	\$0.18	\$ -	211
2	Excavation - Retention Pond	-	CY	\$3.00	\$ -	222
3	Reservoir Liners	-	SF	\$1.15	\$ -	338
4	5" 'Concrete Paver' Pavement	-	SF	\$26.00	\$ -	282
5	18" Concrete Dike	-	LF	\$8.60	\$ -	287
6	6" Asphaltic Rollover Berm	-	LF	\$2.00	\$ -	287
7	Gate Valve	-	EA	\$1,150.00	\$ -	322
8	Grated Inlet	-	EA	\$1,100.00	\$ -	335
9	Trenchdrain	-	LF	\$66.00	\$ -	155
10	12" Reinforced Concrete Pipe	-	LF	\$25.00	\$ -	333
11	Oil Water Separator	-	EA	\$20,800.00	\$ -	376
*RS Means Heavy Construction 2010			Total Cost:		\$ -	

## 5.2 Drawing of Alternative Designs

All six design ideas were drawn into AutoCAD, and the quantities of each construction item were labeled. The drawing for the chosen alternative, Alternative 2, is displayed in Figure 5.1.

As seen in the figure, the 18” dike surrounding the parking area amounts to 111 linear feet in total. The 6” rollover berm at the connection of the parking area to fuel apron pavement was measured to be 39 linear feet. There was only one gate valve used, and the proposed fuel resistant pavement was 36 feet by 40 feet or 1,440 square feet. Similar drawings were created for each of the five alternate drawings and can be found in Appendix G.

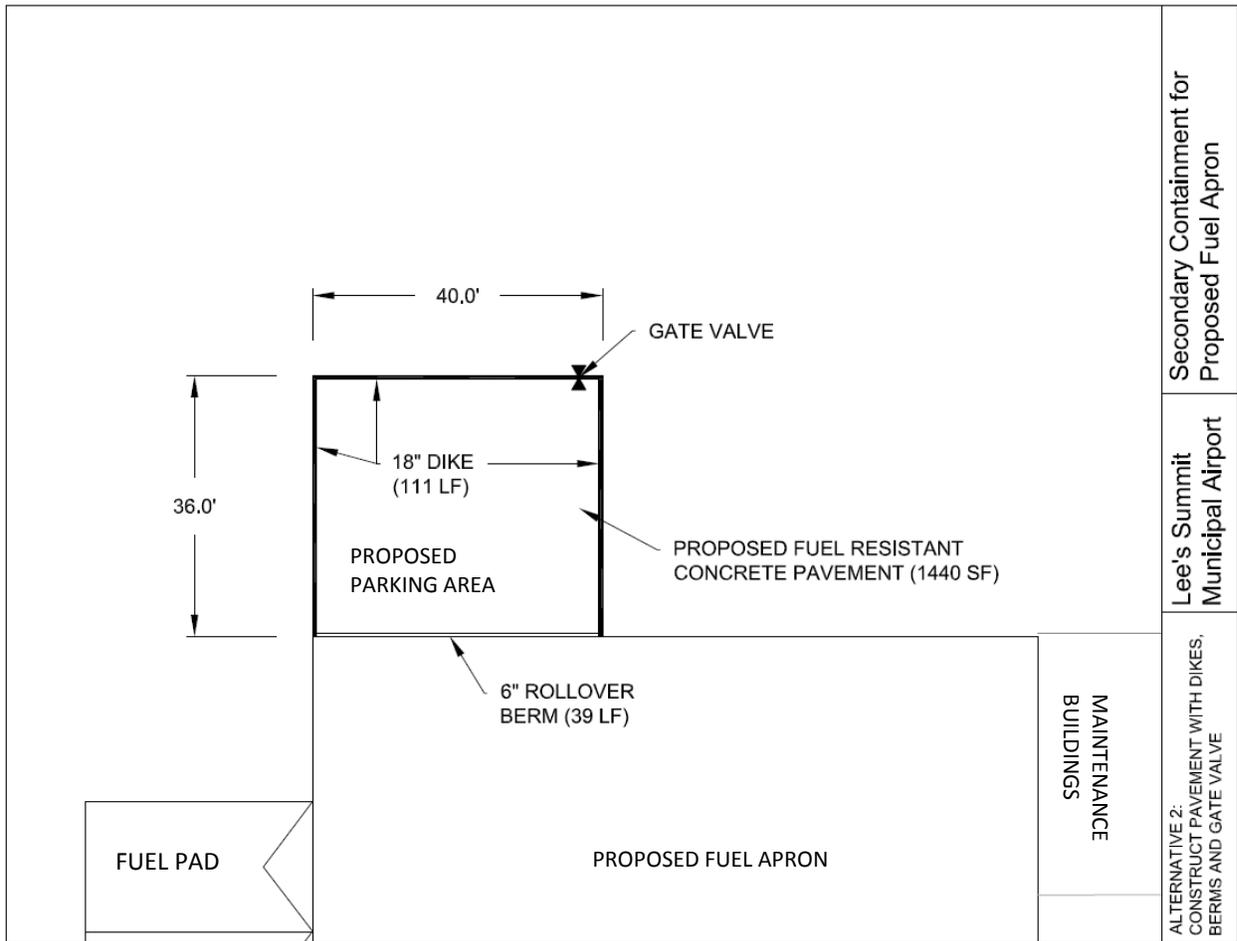


Figure 5.1. Proposed Mobile Refueler Parking Area Design: Alternative 2

### 5.3 Cost Estimations of Alternative Designs

Once the quantity estimations were tabulated for each alternative, the summaries of cost estimates for each alternative were calculated. The cost summary for Alternative 2 is shown in Table 5.2. As shown in the table, the total cost for each construction item was determined by multiplying the estimated quantities found in the drawings with the unit price estimations found in RS Means. When completed, the cost of each separate construction item was displayed and the total overall cost to construct the proposed refueler parking area using Alternative 2 was

concluded to be \$ 39,622.60. Similar spreadsheets were created for each of the five alternate drawings and are displayed in Appendix G.

Table 5.2. Proposed Mobile Refueler Parking Area Opinion of Probable Cost: Alternative 2

Lee's Summit Municipal Airport Proposed Fuel Apron - Secondary Containment <b>Alternative #2 Cost Summary</b>					
No.	Item	Quantity	Unit Type	Unit Price	Cost
4	5" 'Concrete Paver' Pavement	1440	SF	\$26.00	\$ 37,440.00
5	18" Concrete Dike	111	LF	\$8.60	\$ 954.60
6	6" Asphaltic Rollover Berm	39	LF	\$2.00	\$ 78.00
7	Gate Valve	1	EA	\$1,150.00	\$ 1,150.00
<b>Total Cost:</b>					<b>\$ 39,622.60</b>

## 6. Interactions with Industry Experts

During research and analysis, a total of seven industry experts were contacted, including design consultants, airport operation staff and government agencies. These contacts provided valuable information towards the research and analysis of secondary containment.

### 6.1 Consultants

The first source contacted for information was Mr. Ty Sander from Crawford Murphy and Tilly, Inc. (CMT), a regional engineering firm that specializes heavily in airport engineering. Mr. Sander has almost 15 years of experience in the airport consulting industry. As the St. Louis aviation group manager, he has been in charge of a wide variety of airfield construction projects. Mr. Sander was a primary contact throughout the entire process of the research and analysis. He provided many sources regarding fuel regulations on airports, as well as referring most of the other industry experts that were contacted. Ty provided substantial assistance with the design of the six alternatives compared in this study; he explained risks and benefits associated with using

oil-water separators, retention ponds and barrier methods. The preliminary design of the proposed fuel apron at LXT was conducted by CMT; Ty provided the associated drawings and information regarding the fuel apron that was used in the case study.

Ms. Kristin Eder is currently the Senior Environmental Project Manager of Argus Consulting, Inc., a significant provider for fuel system design services in the United States. In a phone interview with Ms. Eder and some of her associates, valuable input was received on the proposed design methods from the perspective of a consulting firm that specializes directly with fueling operations. Advantages and disadvantages to the methods that were researched were discussed, as well as receiving some new methods of secondary containment, such as placing a trenchdrain at the entrance to the parking area. In the conversations a few new innovations in secondary containment were introduced, but none of which applied directly to the case study at Lee's Summit.

## **6.2 Airport Managers and Operations Staff**

Mr. John Ohrazda was a primary contact throughout the entire research and design process. Mr. Ohrazda has been the Airport Manager of Lee's Summit Municipal Airport for over 28 years. In initial discussions he provided the real world examples of advantages and disadvantages to each method of secondary containment that were researched. John emphasized the specific issue with regulation of secondary containment for mobile refuelers, and provided many examples of his personal experiences with the topic.

Originally the plan was to perform the design analysis on a hypothetical situation. With Mr. Ohrazda's assistance, however, it was possible to perform an analysis on designs issue at his airport. He explained that preliminary designs are currently in the works for a proposed fuel

apron at LXT. He further explained that he was interested in the idea of including additional space on the apron with full secondary containment to park the two mobile refuelers that are currently in operation. It was this situation that the entire design analysis was based on.

Mr. Ohrazda allowed a site visit to LXT, a picture of which is shown in Figure 6.1. He gave a tour of his entire airfield, allowing an opportunity to personally observe and analyze the airport operations and the specific areas of interest for the case study, such as the current location of mobile refueler parking and the area where the proposed fuel apron is planned to be.



Figure 6.1. Site Visit to Lee's Summit Municipal Airport

Mr. Dave Schubert recently became the Assistant Airport Direct for Spirit of St. Louis Airport in Chesterfield, Missouri. His prior position at Spirit was Manager of Airport Operations

from 2005 to 2012. Mr. Angel Ramos is currently head engineer of the airport. Mr. Schubert and Mr. Ramos were both directly involved with the conception of Spirit's Spill Prevention Control and Countermeasure (SPCC) plan. As part of the SPCC plan, Mr. Schubert and Mr. Ramos are both listed as the primary individuals responsible for oil spill prevention at the airport.

Contact was made with Mr. Schubert early on in the research on the topic, which led to a phone interview with both Mr. Schubert and Mr. Ramos. This interview provided very helpful information on the topic from the perspective of individuals who are specifically responsible for providing secondary containment. They explained some of the secondary containment methods used at Spirit, and discussed the advantages and disadvantages of many of the methods that were found through research. Mr. Schubert and Mr. Ramos specifically impacted the design of this report by explaining the importance of cost efficiency in fuel-resistant designs. They emphasized how airport operations always lean heavily toward more cost efficient designs, encouraging the use of a cost analysis to be the most substantial portion of the design.

Mr. Don Elliot currently holds the position of Airport Manager for Columbia Regional Airport. His experience with the day to day operations at the airport establishes him as an expert source for information about how fueling systems are operated and environmentally protected. In a brief conversation with Mr. Elliot, information was received concerning how mobile refuelers are operated and how fuel spill containment is controlled at COU

### **6.3 Federal Department Representatives**

Currently holding the position of Missouri Planner, Mr. Todd Madison has worked for the FAA for 23 years. He was referred by Ty Sander as an expert in environmental regulations and policies concerning fueling operations at airports. Mr. Madison provided several sources of

information concerning environmental regulations, specifically regulations in accordance with the FAA, NFPA and EPA. Most importantly, Mr. Madison provided specific details regarding conditions for Airport Improvement Program funding for fuel farms and mobile refueler parking.

## **7. Description of Projected Impacts**

### **7.1 Effectiveness of Design**

The particular design of the use of fuel resistant pavement along with a dike/berm perimeter and gate valve chosen for LXT proves to be an efficient method to provide secondary containment for the mobile refuelers in operation. The design is set to hold a spill from the entire volume of the largest fuel truck during a 25 year rain event. It provides sound passive containment for the refuelers so that if a spill occurs at night with nobody around, it will not seep into any groundwater sources or cause any major damage. The design is also advantageous due to the fact that it can be implemented without any delay in daily operations.

According to cost analyses, it would be more cost efficient to construct the additions to the parking pad than it would be to face the fines and cleanup costs should a full mobile refueler spill occur sometime within the next twenty years. Based on research of data records, it was determined that the likelihood of a major spill occurring for one refueler is approximately a one out of one-thousand (0.1%) chance each year. This means that with two refuelers in operation, there is a 4% chance of a major spill occurring over the next twenty years. As Mr. Ohrazda himself stated, a fuel spill that reaches the arteries of streams leading into Unity Lake would incur severe fines from EPA on top of the costs to clean up the spill. Therefore the estimated cost of fines and cleanup in the event of a major spill occurrence was estimated to be \$1,500,000.

The costs analysis performed is shown in Figure 7.1, and demonstrates that taking preemptive measures proves to be cheaper than reacting to a major fuel spill within the 20 year design life.

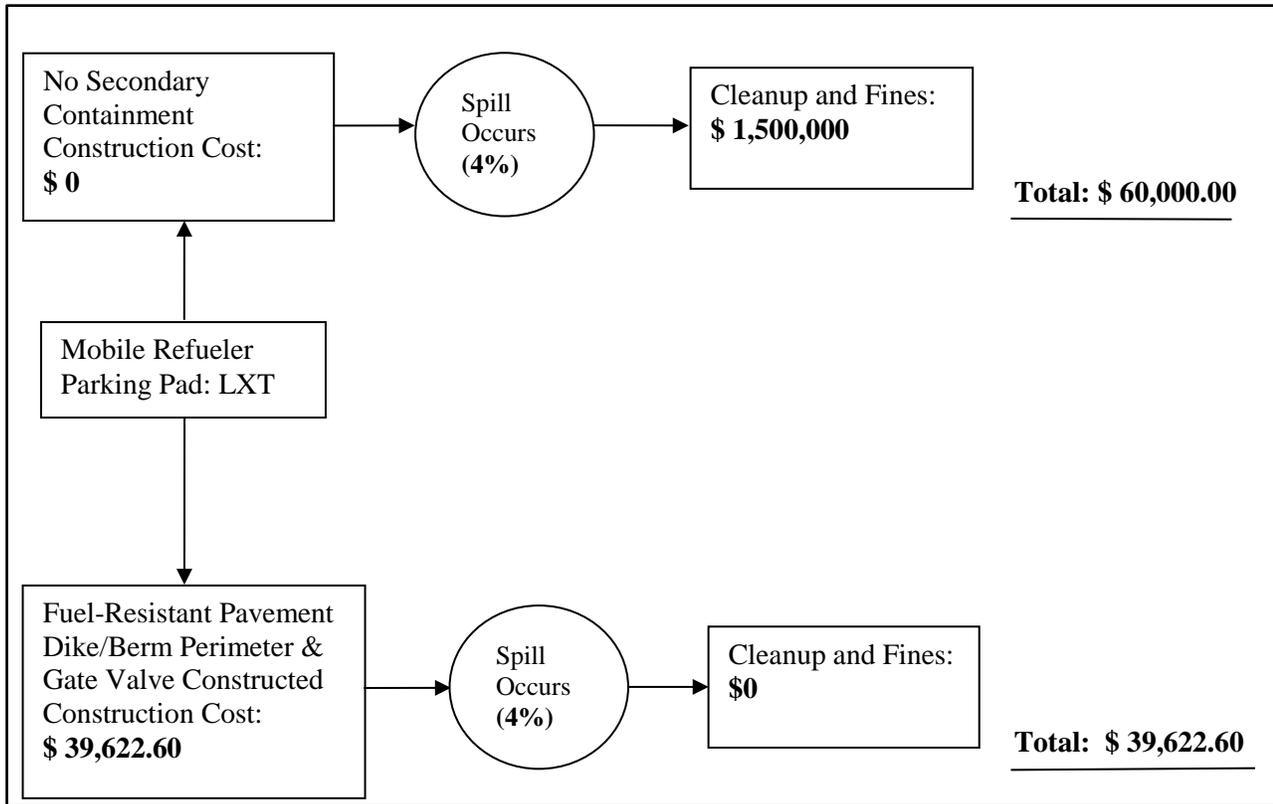


Figure 7.1. Cost Comparison for 20 Year Design Life

## 7.2 Implementation of the Design

Although there are currently no direct regulations in place for the complete secondary containment for mobile refuelers, a spill occurring on airport property would be the responsibility of the airport and could cause the airport to have significant loss of revenue in order to cover the cleanup costs and fines. It would be highly advantageous for an airport manager to include this proposed method of containment to any pavement which mobile refuelers will be parked on in the future. Unlike a traditional containment system, this design

incorporates a number of individual containment components, forming a unique system based on the airport's needs. It could be advantageous to promote this design in guidelines for SPCC plans or for consultants and contractors that work with airports to suggest that this combination of techniques is used more often.

### **7.3 Universal Impact**

Primarily, this study was performed to design a solution for one specific airport. The secondary objective for this analysis, however, was to offer solutions to minimize the effects of mobile refueler oil spills for airports of all sizes. The potential real world impact of this study is to analyze not just one but several different methods of passive secondary containment. For this particular case study, it was decided to ultimately accept the alternative with the lowest cost estimate because LXT is a relatively small airport. When compared to other airports, LXT would experience lower risk and severity of a fuel spill occurring because only two refuelers are in operation. Many other mid-sized and larger airports make use of many refuelers with higher volumes. These airports would also have more money to spend on infrastructure and operations. Therefore, larger airports would be better suited to spend more money on designs of secondary containment of higher quality. In the context of this specific report, it can be determined that the cheapest design of using dikes/berms and a gate valve would be the best fit for LXT, while use of designs including trenchdrains, retention ponds and oil water separators would be better suited for larger airports.

## **Appendix A**

### **Contact Information**

**Faculty Advisor:** Carlos Sun, Ph.D., P.E., J.D.  
University of Missouri

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## **Appendix B**

### **Description of University**

The University of Missouri-Columbia (MU), founded in 1839, is Missouri's first, largest and most comprehensive public university and its primary research institution. MU's primary mission in research and doctoral education provides enhanced opportunities and challenges in the undergraduate areas of humanities, arts, and sciences and in selected professional fields and provides the basis for service to the people of the state via outreach programs. MU continues its historic mission through its emphasis on excellence in instruction, scholarship and service.

MU is one of the most comprehensive and diverse universities in the United States. It is accredited by the North Central Association of Colleges and Secondary Schools. It is also one of only 34 public U.S. universities to be selected for membership in the Association of American Universities and designated "Research University/Very High" by the Carnegie Foundation for the Advancement of Teaching. MU, with its 18 schools and colleges, is a premier provider of undergraduate, graduate and professional education.

The combination of diversity of academic and co-curricular offerings in a predominantly residential student environment at MU promotes interdisciplinary study and research. The comprehensive nature of the University and the breadth of graduate programs and professional schools are distinctive features of the institution. The strength of MU in research, creative achievement, and advanced graduate education enriches the quality of instruction for both undergraduate and graduate students.

## Appendix C

### Description of Non-university Partners

Ty Sander, P.E.  
Aviation Group Manager  
Crawford, Murphy and Tilly, Inc.  
Email: tsander@cmtengr.com

Mr. Sander has almost 15 years of experience in the airport consulting industry working for one of the top airport consultants in the Midwest: Crawford Murphy and Tilly, Inc. (CMT). As the St. Louis aviation group manager, Ty has been in charge of a wide variety of airfield construction projects and has won many awards from reputable organizations.

John Ohrazda  
Airport Manager  
Lee's Summit Municipal Airport  
Email: John.Ohrazda@cityofls.net

John has been the Airport Manager of Lee's Summit Municipal Airport for over 28 years. His experience overlooking the day-to-day operations of LXT establishes him as an expert to airport fueling operations and the control and containment of mobile refueler fuel spills.

Don Elliott  
Airport Manager  
Columbia Regional Airport

Mr. Elliot has long held the position of Airport Manager for Columbia Regional Airport. His experience with the day to day operations at the airport establish him as an expert source for information about how fueling systems are operated and environmentally protected.

Todd Madison  
FAA Central Region  
Airports Capacity Program Manager and Missouri Planner  
FAA Central Region Airports Division, ACE-611B

Email: todd.madison@faa.gov

Currently holding the position of Missouri Planner, Mr. Madison has worked for the FAA for 23 years. He was referred by Ty Sander as an expert in environmental regulations and policies concerning fueling operations at airports. Mr. Madison provided the group with several sources of information concerning environmental regulations, specifically regulations in accordance with the FAA, NFPA and EPA. Most importantly, Mr. Madison provided specific details regarding conditions for AIP funding for fuel farms and mobile refueler parking.

Dave Schubert  
Assistant Airport Director  
Spirit of St. Louis Airport  
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Angel Ramos, P.E.  
Airport Engineer  
Spirit of St. Louis Airport  
Email: ARamos@stlouisco.com

Mr. Schubert has recently obtained the position of Assistant Airport Direct for Spirit of St. Louis Airport in Chesterfield, Missouri. His prior position at Spirit was Manager of Airport Operations from 2005 to 2012. Mr. Ramos is currently designated head engineer of the airport. Mr. Schubert and Mr. Ramos were both directly involved with the conception of Spirit's Spill Prevention Control and Countermeasure (SPCC) plan. As part of the SPCC plan, Mr. Schubert and Mr. Ramos are both listed as the primary individuals responsible for oil spill prevention at the airport.

Kristin M. Eder, REM  
Sr. Environmental Project Manager  
Argus Consulting, Inc.  
Email: keder@argusconsulting.com

Ms. Eder is currently the Senior Environmental Project Manager of Argus Consulting, Inc. Argus is a significant provider for fuel system design services in the United States, accounting for work with 70 percent of the top 100 airports in the United States. Ms. Eder was a valuable source of information to purvey the concept of secondary containment from the perspective a consulting firm that specializes directly with fueling operations.

## **Appendix E**

### **Evaluations of Educational Experience**

#### **Tyler Horn**

I personally intend to work as an airport engineer upon graduation. The FAA competition created a valuable learning experience because it allowed me to prepare for the future by addressing work similar to what is done in an airport consulting firm such as research, interactions, technical analysis and presenting an organized summary of all of our work.

A challenge we faced early on in our work was that we researched several means of secondary containment but were unsure on how to decide on one. We then developed the idea to perform a case study and implement each idea to an actual airfield using AutoCAD, from this we made cost estimations and were able to determine which one would work the best.

We developed our initial hypothesis by doing preliminary research, and deciding we were going to take a stance with a seemingly important issue today: countering fuel spills on airfields. As we researched, our overall outlook for our design idea continuously changed and evolved as we progressed further into our work. As we were researching our topic we narrowed our field of study from general secondary containment to addressing the matter specifically for mobile refuelers. After speaking to airport directors we decided to turn our project into a case study. Our hypothesis evolved as we worked and we were able to work through and adapt to new ideas in order to continuously improve our project.

Interacting with industry experts for this research was very useful and rewarding. Over the course of our research we spoke with airport operating staff, airport consultants and

government workers. Staying in constant contact with many of the experts helped us discover methods of secondary containment as well as the advantages and disadvantages of each method through different perspectives.

Over the course of the project I gained a lot of experience and really enjoyed being involved with people internally and externally. I also learned a lot of technical knowledge about fuel spills and the related environmental policies and design techniques. This project really reinforced my interest in working for an engineering consultant in the airport industry. I feel that it has been an appropriate experience for me to face in my final year of college and it has been a huge part of my preparation to begin my career.

### **Ericka Ross**

Participating in the FAA Design Competition was definitely a meaningful experience for me because it gave me experience working on a team as well as learning more about airports and FAA regulations. The knowledge gained from this competition has enlightened me on current issues regarding airports that I did not even know existed before the start of the competition project.

I think one of the main challenges that our team incurred during the competition was that we tried to go too in depth into many design approaches. We had to change our focus more on a few particular solutions. We decided to use a smaller airport as a case study in order to make the design approach more focused.

Our team picked a topic that we were all interested in, and then decided to do some initial research on the issue including cost to clean up spills, current regulations, history of spills, and

different pavements. We narrowed down our research to do a case study and apply a cost analysis in order to find the most cost effective solution for our case study. Once the research was done, we all divided the parts of the report and completed each section accordingly.

Going on site to the Lee's Summit Airport as well as having personal interaction with the director of the airport was helpful in completing this project. We were able to see the mobile refuelers as they were used and also where they were currently parked when not being used. This helped us decide on the different solutions that we wanted to propose. The director gave us feedback on what he might actually consider for his airport as well as what his issues might be with some of our solutions.

I learned that large fuel spills are not very common or probable to happen, but if one was to happen, the cleanup would be very costly. I learned that making a cost effective solution that would help prevent contamination in the event of a large spill would be better than just taking a chance that it will not happen. This competition helped me incur interest in airports, and make me more interested in possibly pursuing a job in the airports industry.

### **Austin Ratzki**

The FAA Design competition was definitely a meaningful learning experience for me because it gave me a hands on experience to research and develop a reasonable solution that had to fit professional guidelines all the while working with team members. No matter what field of engineering any of my team members or I enter, this competition will prove valuable to our success. The design competition gave "teeth" to what I was learning not only in my class on

airport design and FAA regulations but all my classes where I learned about creating and developing engineering solutions.

I think the largest challenge that our team faced was that the issue we chose to design a solution for has made such large strides in the recent past that we did not realize until after talking to professionals. We had already overcome some of this problem as we researched many ways to help contain or clean up fuel spills, giving us alternatives that might make our solution one that was just cost efficient from procedures already in place. We also used this as an opportunity to delve into the problem more and develop our solution to be more specific to what the industry needs. We were able to ask professionals with a new, more driven thought process and got our result from that.

As I just mentioned, we had to narrow down our fuel spill focus into what ended up being building a cost effective fuel spill containment area for our airport. We started by of course seeing what was deemed a problem in the industry that we had interest in. We chose fuel spills and researched current regulations on them, pavement types and issues with spills, containment areas (both natural and man-made), cleaning techniques, etc. We narrowed down our solution into containment areas and talked to industry professionals about what their typical budgets and expectations would be for such a solution. We split up these tasks evenly throughout as there were many other aspects to this project than just the solution.

Participation by the industry in the project was very appropriate, meaningful, and useful. As I have stated above we used many a professionals' opinion on the topic and it helped us really in the end make a great solution in our opinion. We were even invited by a professional in charge of the airport we chose to visit and see first-hand the on goings of the airport and actually visualize where our design would be. That on site experience really made us confident in

proceeding with our design as well as gave us ideas to change or alter the solution to better fit the area.

I learned first and foremost the expectation of a professional project that might occur in any workplace setting. I understand the scope and hoops one has to jump through to make a successful and credible design when dealing with any regulations on projects. This project gave me and my teammate's confidence that we can break these things into parts over time and amongst us to change the entire project from big picture into a lot smaller, reasonable parts. All in all, this project will be one I can definitely use and refer back to when entering the workforce in the near future.

### **Eric Trupiano**

The FAA Design Competition was a very meaningful experience. My favorite aspect of our research was the interaction with industry experts. Not only did I learn more about the aviation industry, I also learned a great amount about the civil engineering profession, including management, design, and consulting.

It was very difficult to display the most important information without being redundant over a report as long as this one. Walking the line between effective repetition and overkill proved difficult, but was solved after heavy amounts of editing. It was also different to maintain consistent sentence structure with four people each writing different parts of the report. Editing again solved this problem.

After identifying the problem, we identified individual tools that could be used to solve our problem such as asphalt berms and trench drains. After finding individual components that would solve our problem, we incorporated them into six different designs using AutoCAD then

found the total cost estimation using R.S. Means 2010. We then chose the best design pertaining to our case study based on effectiveness and cost.

Participation of industry experts proved beneficial to the group throughout the research and design process. Using their knowledge, we were able to create designs that are both realistic and economical. We also gained insight as to how airports operate on a day-to-day basis.

I learned a great deal about the aviation industry as a whole. Specifically, we learned about the state and federal regulations that airports are subject to as well as the preventative measures taken to avoid and treat fuel spills. We learned about the operating schedules of airports of different sizes and types and became familiar with the priorities of each. In addition, we gained some insight into the future of the aviation industry and how things can potentially change as technology improves.

## Appendix F

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# **Appendix G**

## **Alternate Design Solution Cost Analyses**

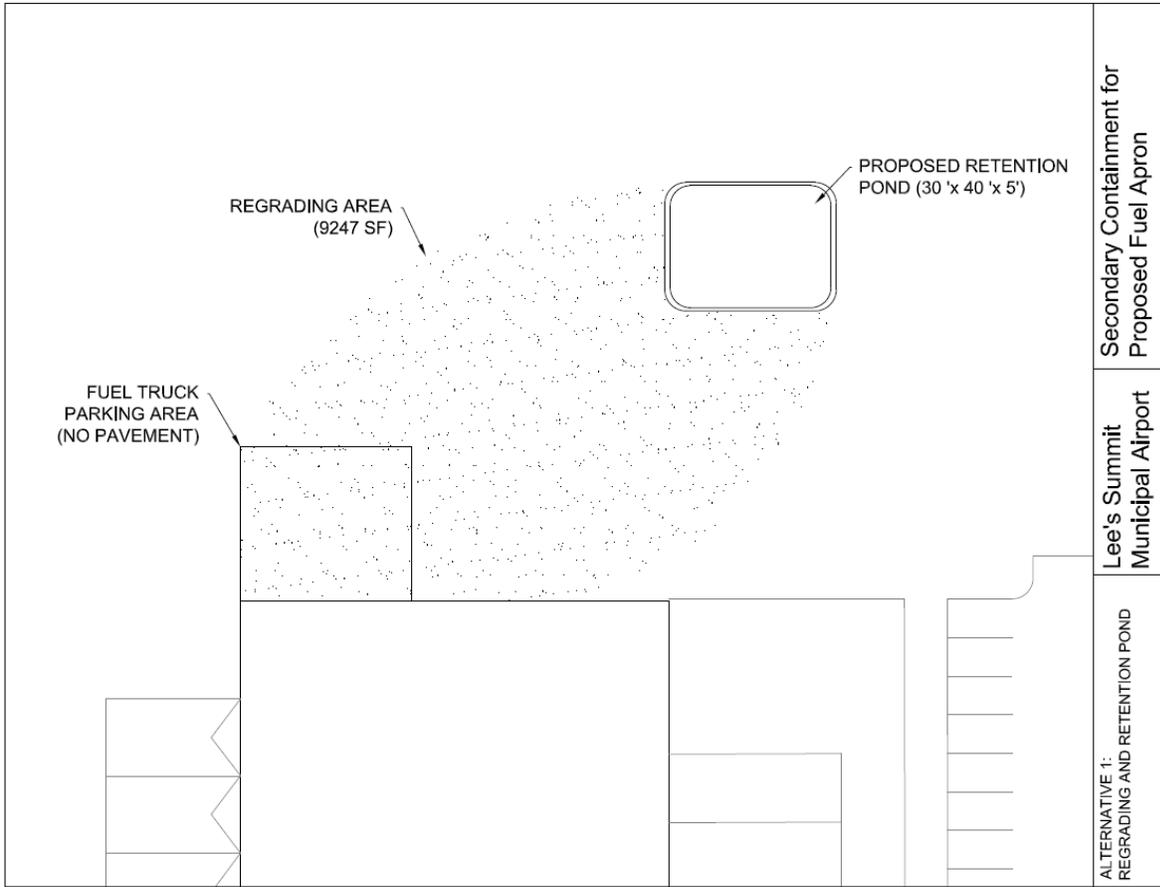


Figure G.1. Proposed Mobile Refueler Parking Area Design: Alternative 1

Table G.1. Proposed Mobile Refueler Parking Area Opinion of Probable Cost: Alternative 1

Lee's Summit Municipal Airport Proposed Fuel Apron - Secondary Containment <b>Alternative #1 Cost Summary</b>					
No.	Item	Quantity	Unit Type	Unit Price	Cost
1	Grading	3082	SY	\$0.18	\$ 554.76
2	Excavation - Retention Pond	222	CY	\$3.00	\$ 666.00
3	Reservoir Liners	1200	SF	\$1.15	\$ 1,380.00
				<b>Total Cost:</b>	<b>\$ 2,600.76</b>

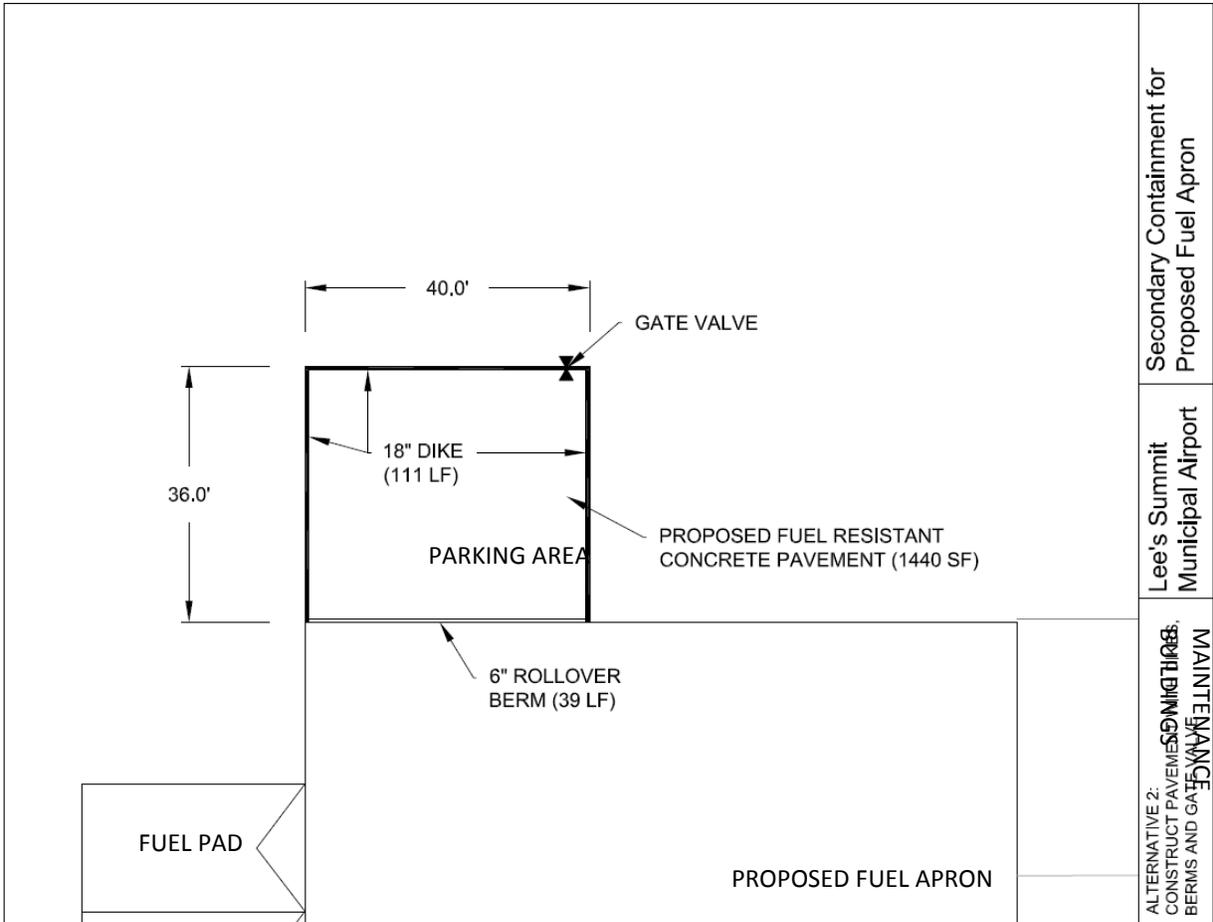


Figure G.2. Proposed Mobile Refueler Parking Area Design: Alternative 2

Table G.2. Proposed Mobile Refueler Parking Area Opinion of Probable Cost: Alternative 2

Lee's Summit Municipal Airport Proposed Fuel Apron - Secondary Containment <b>Alternative #2 Cost Summary</b>					
No.	Item	Quantity	Unit Type	Unit Price	Cost
4	5" 'Concrete Paver' Pavement	1440	SF	\$26.00	\$ 37,440.00
5	18" Concrete Dike	111	LF	\$8.60	\$ 954.60
6	6" Asphaltic Rollover Berm	39	LF	\$2.00	\$ 78.00
7	Gate Valve	1	EA	\$1,150.00	\$ 1,150.00
<b>Total Cost:</b>					<b>\$ 39,622.60</b>

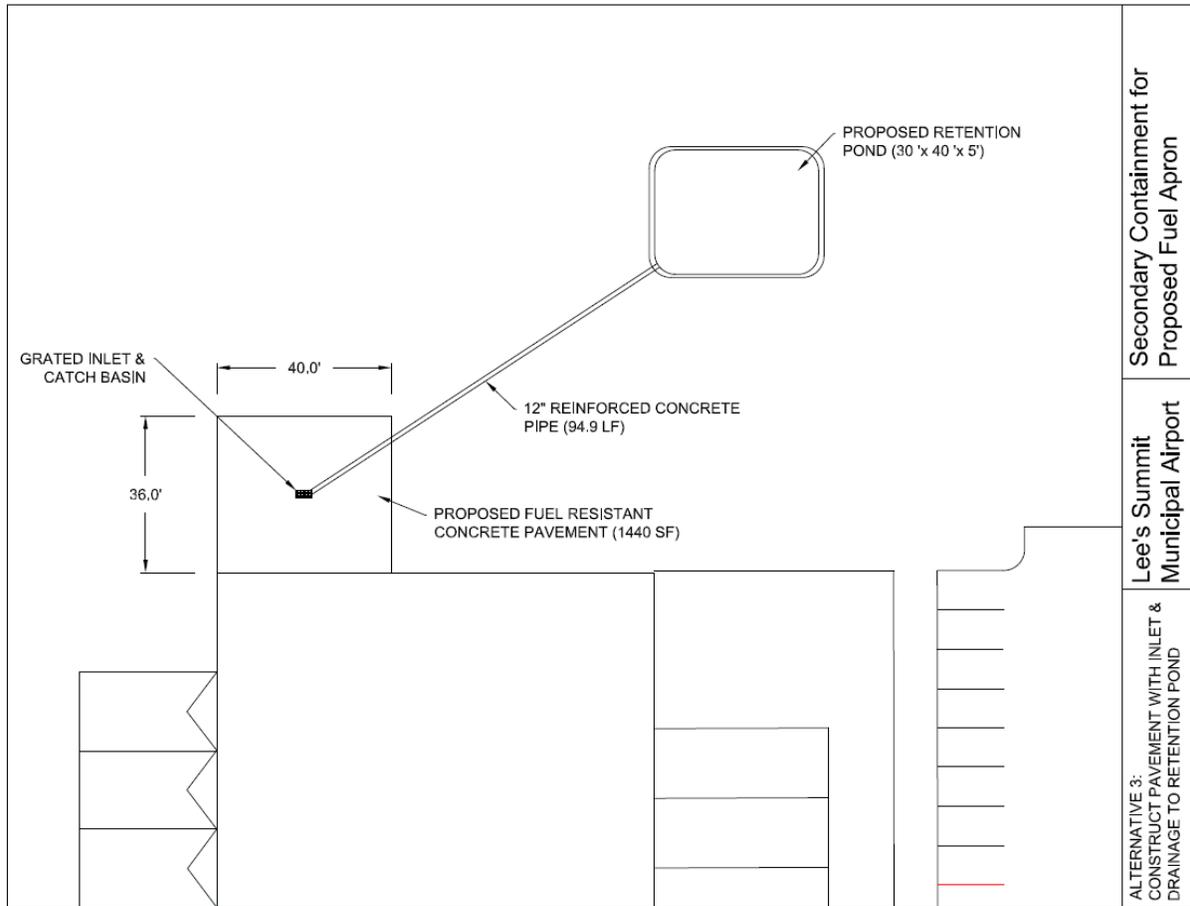


Figure G.3. Proposed Mobile Refueler Parking Area Design: Alternative 3

Table G.3. Proposed Mobile Refueler Parking Area Opinion of Probable Cost: Alternative 3

Lee's Summit Municipal Airport Proposed Fuel Apron - Secondary Containment <b>Alternative #3 Cost Summary</b>					
No.	Item	Quantity	Unit Type	Unit Price	Cost
1	Grading	3082	SY	\$0.18	\$ 554.76
2	Excavation - Retention Pond	222	CY	\$3.00	\$ 666.00
3	Reservoir Liners	1200	SF	\$1.15	\$ 1,380.00
4	5" 'Concrete Paver' Pavement	1440	SF	\$26.00	\$ 37,440.00
8	Grated Inlet	1	EA	\$1,100.00	\$ 1,100.00
10	12" Reinforced Concrete Pipe	94.9	LF	\$25.00	\$ 2,372.50
<b>Total Cost:</b>					<b>\$ 43,513.26</b>

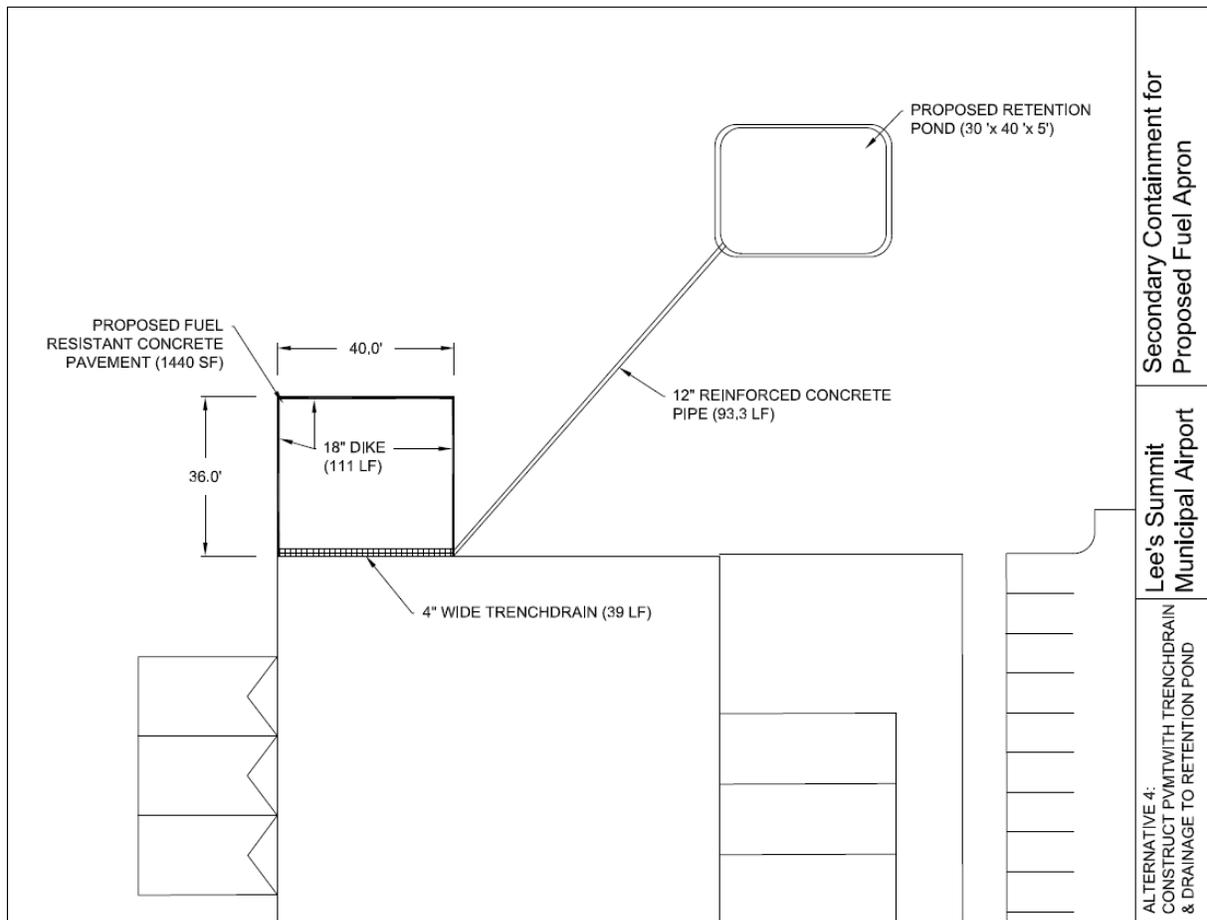


Figure G.4. Proposed Mobile Refueler Parking Area Design: Alternative 4

Table G.4. Proposed Mobile Refueler Parking Area Opinion of Probable Cost: Alternative 4

Lee's Summit Municipal Airport Proposed Fuel Apron - Secondary Containment <b>Alternative #4 Cost Summary</b>					
No.	Item	Quantity	Unit Type	Unit Price	Cost
1	Grading	3082	SY	\$0.18	\$ 554.76
2	Excavation - Retention Pond	222	CY	\$3.00	\$ 666.00
3	Reservoir Liners	1200	SF	\$1.15	\$ 1,380.00
4	5" 'Concrete Paver' Pavement	1440	SF	\$26.00	\$ 37,440.00
5	18" Concrete Dike	111	LF	\$8.60	\$ 954.60
9	Trenchdrain	39	LF	\$66.00	\$ 2,574.00
10	12" Reinforced Concrete Pipe	93.3	LF	\$25.00	\$ 2,332.50
Total Cost:					\$ 45,901.86

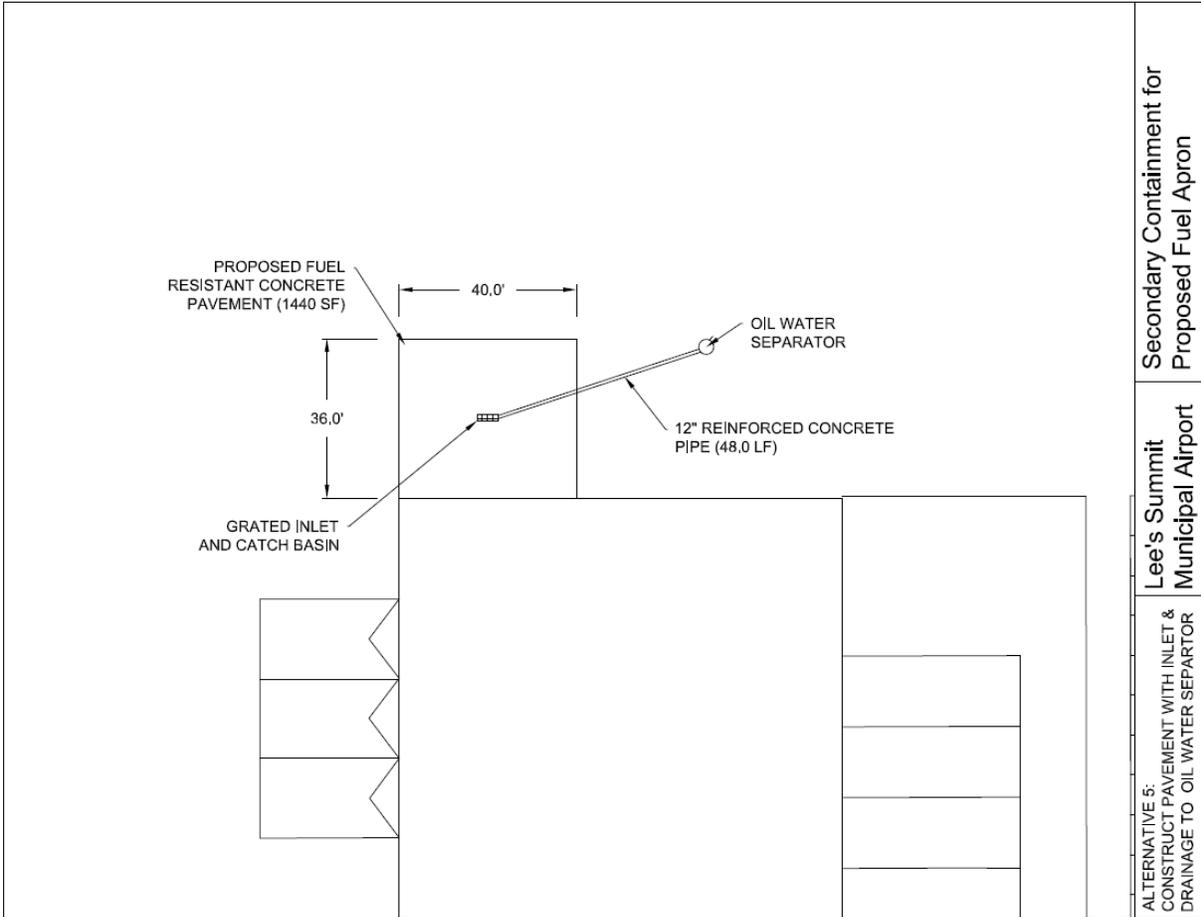


Figure G.5. Proposed Mobile Refueler Parking Area Design: Alternative 5

Table G.5. Proposed Mobile Refueler Parking Area Opinion of Probable Cost: Alternative 5

Lee's Summit Municipal Airport Proposed Fuel Apron - Secondary Containment <b>Alternative #5 Cost Summary</b>					
No	Item	Quantity	Unit Type	Unit Price	Cost
4	5" 'Concrete Paver' Pavement	1440	SF	\$26.00	\$ 37,440.00
8	Grated Inlet	1	EA	\$1,100.00	\$ 1,100.00
10	12" Reinforced Concrete Pipe	48	LF	\$25.00	\$ 1,200.00
11	Oil Water Separator	1	EA	\$20,800.00	\$ 20,800.00
<b>Total Cost:</b>					<b>\$ 60,540.00</b>

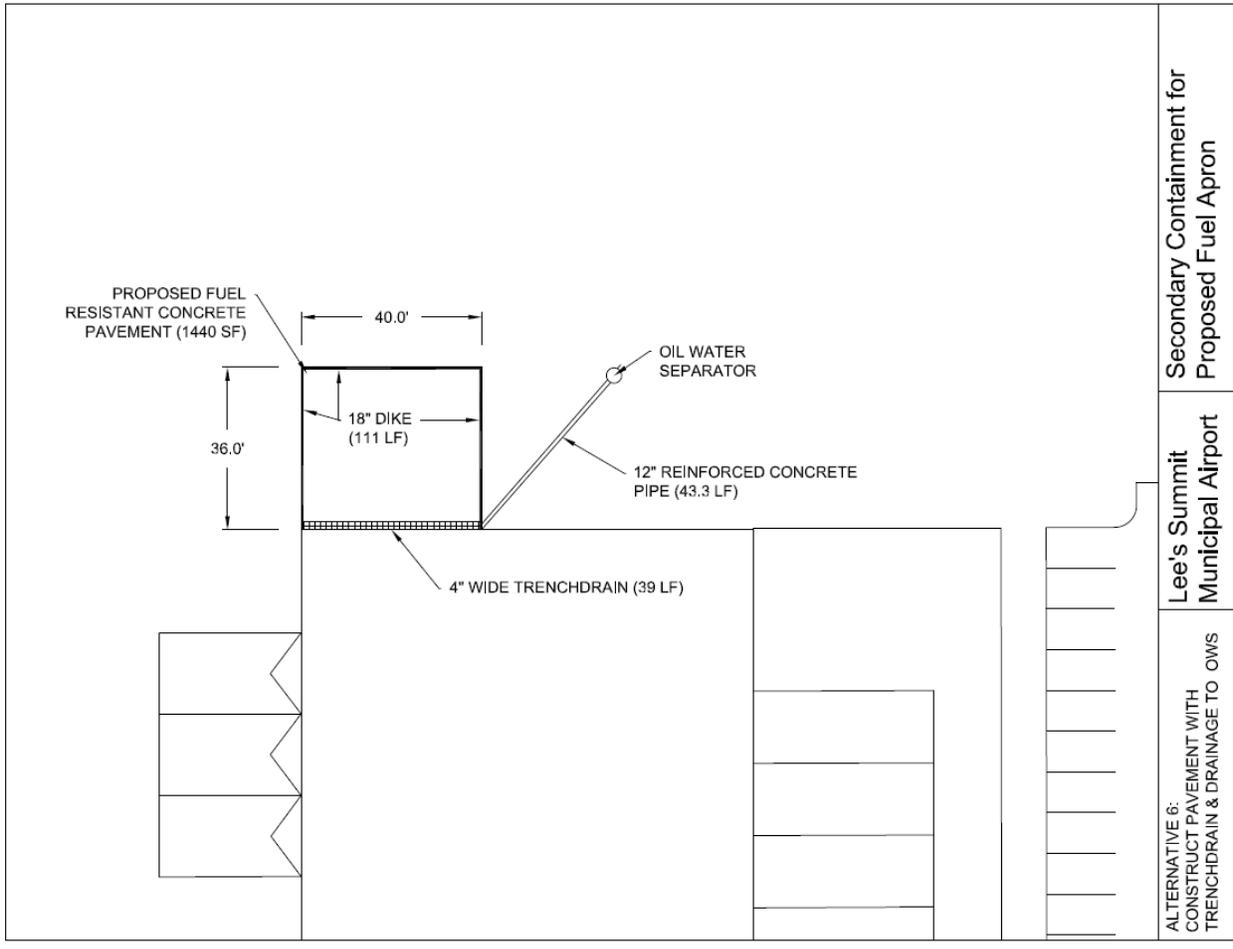


Figure G.6. Proposed Mobile Refueler Parking Area Design: Alternative 6

Table G.6. Proposed Mobile Refueler Parking Area Opinion of Probable Cost: Alternative 6

Lee's Summit Municipal Airport Proposed Fuel Apron - Secondary Containment <b>Alternative #6 Cost Summary</b>					
No.	Item	Quantity	Unit Type	Unit Price	Cost
4	5" 'Concrete Paver' Pavement	1440	SF	\$26.00	\$ 37,440.00
5	18" Concrete Dike	111	LF	\$8.60	\$ 954.60
9	Trenchdrain	39	LF	\$66.00	\$ 2,574.00
10	12" Reinforced Concrete Pipe	43.3	LF	\$25.00	\$ 1,082.50
11	Oil Water Separator	1	EA	\$20,800.00	\$ 20,800.00
Total Cost:					\$ 62,851.10