

Research Report
KTC -11-21/SPR384-09-1S

Implementation of Lessons Learned from Change Orders

A SUPPLEMENT TO KYSPR 09-384

Technical Report Documentation Page

1. Report No. KTC11-21/SPR384-09-1S	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Implementation of Lessons Learned from Change Orders A Supplement to KYSPR 09-384		5. Report Date September 2010
		6. Performing Organization Code
2. Author(s) Paul M. Goodrum, Timothy R.B. Taylor, William Lester, Alex McCoy, Mohammed M. Uddin, and Yongwei Shan	8. Performing Organization Report No. KTC11-21/SPR384-09-1S	
9. Performing Organization Name and Address Kentucky Transportation Center College of Engineering University of Kentucky Lexington, Kentucky 40506-0281	10. Work Unit No. (TRAIIS)	
	11. Contract or Grant No. KYSPR 384-09	
	13. Type of Report and Period Covered Supplemental Implementation Resource	
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet State Office Building Frankfort, Kentucky 40622	14. Sponsoring Agency Code	
	15. Supplementary Notes Prepared in cooperation with the Kentucky Transportation Cabinet and the U.S. Department of Transportation, Federal Highway Administration	

Preface

Which change orders tend to have the greatest impact on Kentucky transportation projects? How can I avoid them on future projects? If I do have a change order, what process can I follow to estimate a fair price for both the Cabinet and the Contractor? These are some of the questions that were addressed by research project *Change Orders and Lessons Learned* (KYSPR 09-384) at the University of Kentucky's Kentucky Transportation Center.

Why the Need for this Supplement?

Traditional research reports through the Kentucky Transportation Center contain a significant amount of scientific and technical discussion regarding the research activities and ultimately how these activities satisfied the project's objectives. The research report for KYSPR-09-384 is no exception. That report fully describes the data mining, statistical analyses, literature reviews, and field interviews that went into developing the results. While these activities and supporting discussions need to be archived through traditional technical reports for future researchers and to answer technical questions on behalf of the Cabinet, a resource that clearly presents the results in a form that is quickly and effectively useful to the Cabinet is needed. This supplement is an implementation resource that presents the products of KYSPR 09-384 without going into the details of the analyses that lead to the creation of the products. The KYSPR-09-384 full technical report contains the full depth of the analyses and supporting discussion if the reader should so choose to need further detail than contained herein.

When should this Supplement be used on Projects?

There are three primary times when the Supplement should be useful to the Cabinet:

- 1 Constructability Reviews** – The supplement presents a number of charts that indicate the likely impact that specific change orders have had on previous Kentucky transportation projects. Using past performance to predict the future, the charts are presented as a predictor of the change orders that may likely occur on future projects. Reviewing the charts during a constructability review

can affect what to review during the Cabinet’s constructability process in order to avoid the same change orders on future projects.

2 During Construction – It is impossible to expect that all change orders can be avoided. When a change order does occur, it is obviously in the best interest of both the Cabinet and the Contractor to agree to a fair price. In order to reach this agreement during the construction, Section Engineers need to know how to effectively price a change order. The supplement outlines a structured process for doing so best on a combination of best practices among experienced Section Engineers and other state transportation agencies.

3 New Employee Orientation – Knowing what change orders can occur during construction is the first step towards minimizing their impact during construction. This was evident as researchers spoke to a number of the Cabinet’s Section Engineer’s during the research. Unfortunately, many young engineer’s lack this experience and knowledge. Referencing this supplement in order to know what to look out for during construction can help beginning Cabinet construction engineers to begin to better effectively manage change orders early during their careers.

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Chapter 1: What are the Risks from Change Orders on Kentucky Transportation Projects?

Quick Guides – What Specific Change Order Codes are most Problematic?

Reference cards were developed with the intention of aiding the Cabinet in quickly determining the causes and project characteristics of greatest concern with regards to change orders on current and future construction projects. The Quick Guides are based on extensive statistical analyses on previous Kentucky transportation projects, which are described in detail in KYSPR-09-384 Change Orders and Lessons Learned Report. To begin understanding how to use the Quick Guides, it is important to define what “impact” means herein. Impact is defined as the percent change multiplied by the frequency of the specific change orders that have occurred on previously completed Kentucky transportation projects. . Examining the impact identifies the areas of greatest concern with regard to change in order to most efficiently allocate the Cabinet’s resources for minimizing the same change orders on future projects.

Each Quick Guide indicates the level of risk for specific change order codes on different project characteristics. Specifically, four Quick Guides indicates the risk of change order impact by:

- Road Type;
- New Construction and Maintenance Projects; and
- Type of Construction (Earthwork, Road Surfacing, and Structures)

Risk is defined as Low, Medium, and High, which are defined as follows:

- **Low Risk** – A specific change order code typically occurs less often than most other change order codes, and when it occurs results in smaller than average increase in the contract price.
- **Medium Risk** – A specific change order code is typical on most Kentucky transportation project and when it occurs results in an average increase in the contract price, compared to other change orders.

- **High Risk** – A specific change order code occurs more frequently than other change orders and results in higher than average increases in contract price when it occurs.

It is important to note that not all change order codes are presented in the Quick Guides. Only those codes that had sufficient amount of data in the research analyses are included in the guide. **Finally, every project is unique and as such circumstances may occur that causes change orders to have a greater or lesser impact than indicated in the following Quick Guides.**

Quick Guide: Risk of **IMPACT** by Reason Code and Road Type

Reason Code	Description	Road Type				
		CR	PW	KY	US	I
1	Asphalt Lot Pay Adjustment	○	○	●	●	○
3	Fuel & Asphalt Adjustment	●	●	●	●	●
4	Contract Omission	●	●	●	●	●
5	Utility Issue	●	---	○	○	○
6	Contract Item Overrun	●	●	●	●	●
7	Geotechnical Issues	---	●	●	●	○
8	Owner Induced Enhancement	●	●	●	●	●
9	Environmental Issues	---	---	●	○	○



Low Risk of impact



Risk of impact



Extreme Risk of impact

--- Data Insufficient

CR: County Road

PW: Parkway

KY: State

US: US

I: Interstate

Figure 1: Quick Guide – Risk of Impact by Reason Code and Road Type

Quick Guide: Risk of **IMPACT** by Reason Code and New/Maintenance Projects

Reason Code	Description	New	Maintenance
1	Asphalt Lot Pay Adjustment	○	●
3	Fuel & Asphalt Adjustment	●	●
4	Contract Omission	●	●
5	Utility Issue	●	●
6	Contract Item Overrun	●	●
7	Geotechnical Issues	●	○
8	Owner Induced Enhancement	●	●
9	Environmental Issues	●	○

- Low Risk of impact
- Risk of impact
- Extreme Risk of impact

Figure 2: Quick Guide – Risk of Impact by Reason Code and New Construction/Maintenance Projects

Quick Guide: Risk of **IMPACT** by Reason Code and Construction Type

Reason Code	Description	Earthwork	Road Surface	Structure
1	Asphalt Lot Pay Adjustment	●	●	○
3	Fuel & Asphalt Adjustment	●	●	●
4	Contract Omission	●	●	●
5	Utility Issue	●	○	○
6	Contract Item Overrun	●	●	●
7	Geotechnical Issues	●	○	○
8	Owner Induced Enhancement	●	●	●
9	Environmental Issues	●	○	○



Low Risk of impact



Risk of impact



Extreme Risk of impact

Earthwork: Grade & Drain, Flood/Slide Repair

Road Surface: Asphalt Surfacing, Asphalt Resurfacing, Jointed Plain Concrete

Structure: Bridge Work, Culvert Replacement, Guardrail, Pipe Replacement

Figure 3: Quick Guide – Risk of Impact by Reason Code and Construction Type

Risk Matrices – What Specific type of Work increases Change Order Risks?

One natural action to follow after reviewing the Quick Guides is to focus on specific work items that increase change order risks. The risk matrices shown below identify the frequency and the average percent change in contract price from common work items. The research developed six risk matrices that focus on the high risk change order codes identified in the quick guides and other change order codes of concern including:

- Contract Omissions
- Contract Item Overruns
- Owner Induced Enhancements; and
- Utility Issues
- Geotechnical Issues
- Contract Item Underrun.

The analysis found that Contract Omissions, Contract Item Overruns, and Owner Induced Enhancement to be three of the change order codes with consistent high impacts. Change order codes related to Utility Issues, Geotechnical Issues, and Contract Item Underrun were found to have a lesser impact and are included in the appendix. For each matrix, the work items are divided into the following work categories, which correspond to an aggregate of common bid items:

- Aggregate
- Asphalt Bases
- Guardrail and Barrier
- PCC Pavement
- Earthwork
- Curb, Gutter and Sidewalk
- Pavement striping and Marking
- Erosion Control and Landscaping
- Signs and Signaling
- Steel Reinforcement
- Utility Piping

- Railroads
- Fences
- Demolition

Each matrix conveys the magnitude and nature of risks associated with change orders in each work category. For example, a category that falls into the upper, right quadrant of the chart indicates a change that occurs relatively frequently and that typically results in a relatively large increase in the cost of the project.

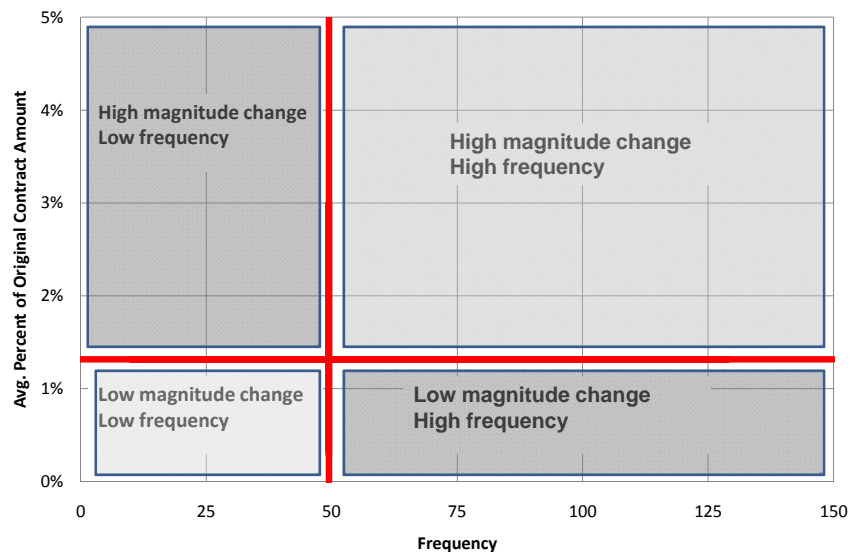


Figure 4: Generic Risk Chart for Work Item Risk Analysis

From a risk management perspective, categories that fall in the upper right quadrant should receive risk mitigation attention first because they happen more frequently and, on average, result in large cost increases. Categories falling within the upper left and lower right quadrant should receive risk mediation attention next because they either occur frequently with low average cost increases or infrequently with high average cost increases when they do occur. Finally, those categories in the lower left quadrant should receive risk mitigation attention last because they occur infrequently and have, on average, minimal cost impacts when they do occur.

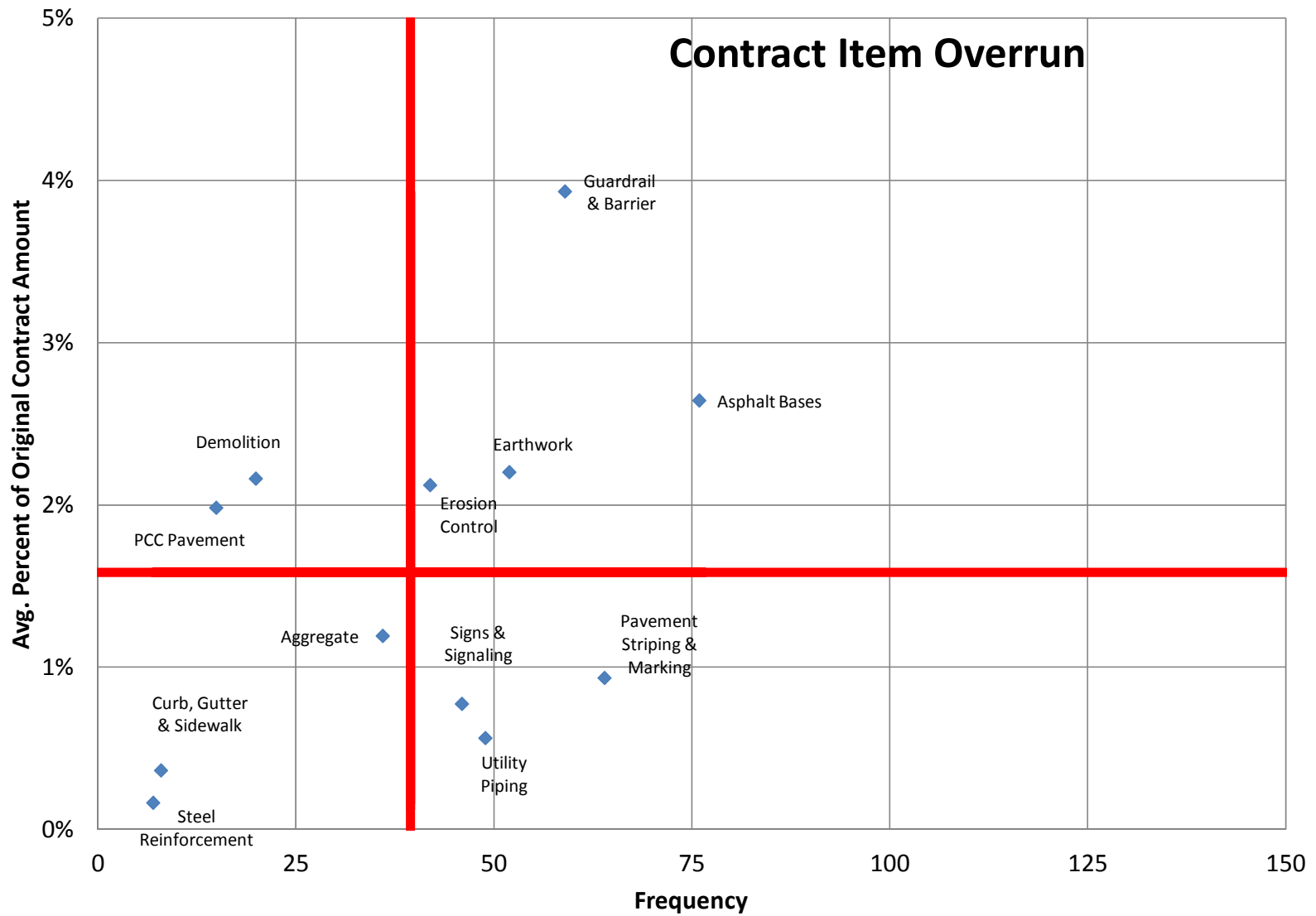


Figure 5: Work Type Risk Analysis Matrix – Contract Item Overrun

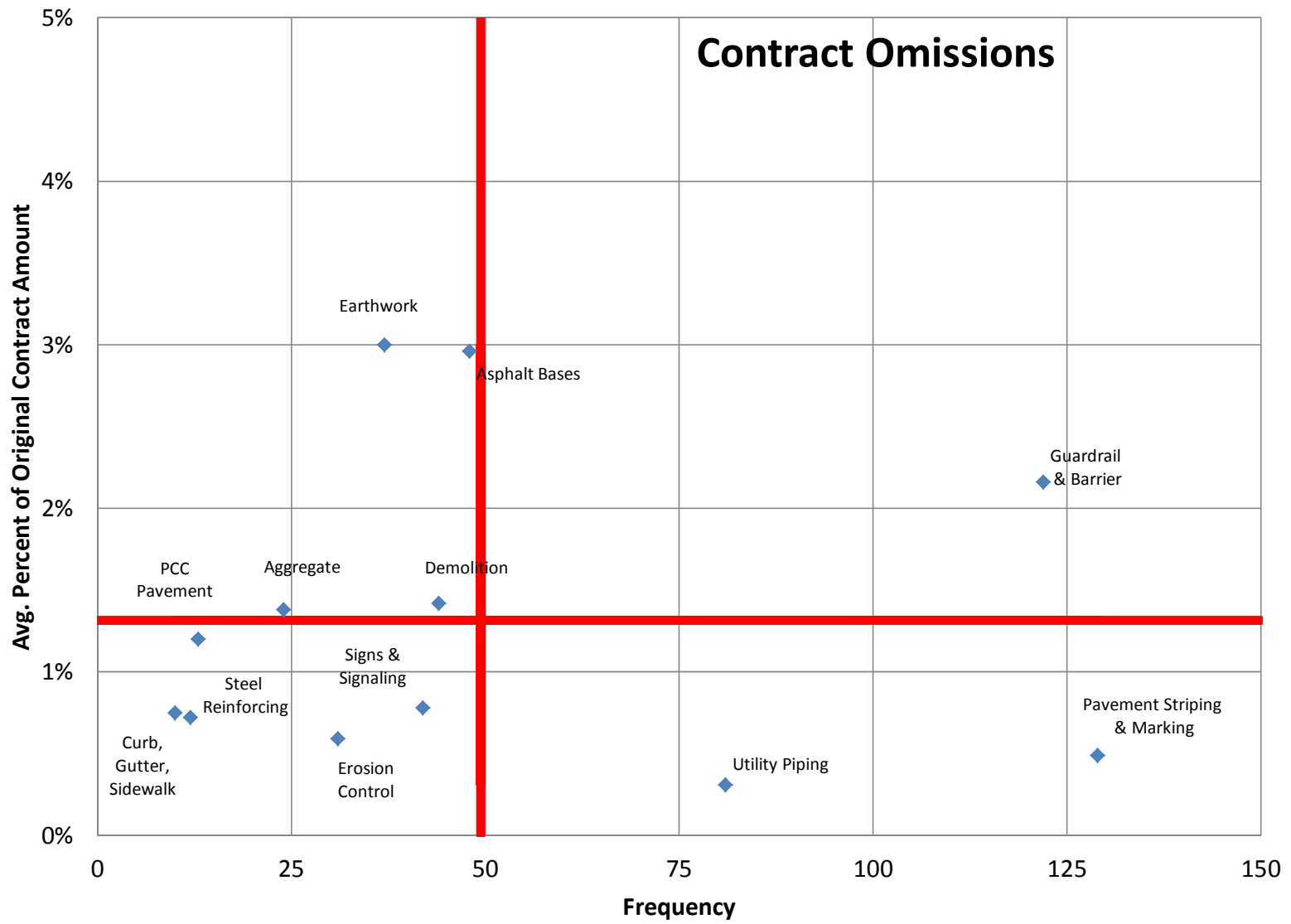


Figure 6: Work Type Risk Analysis Matrix – Contract Omissions

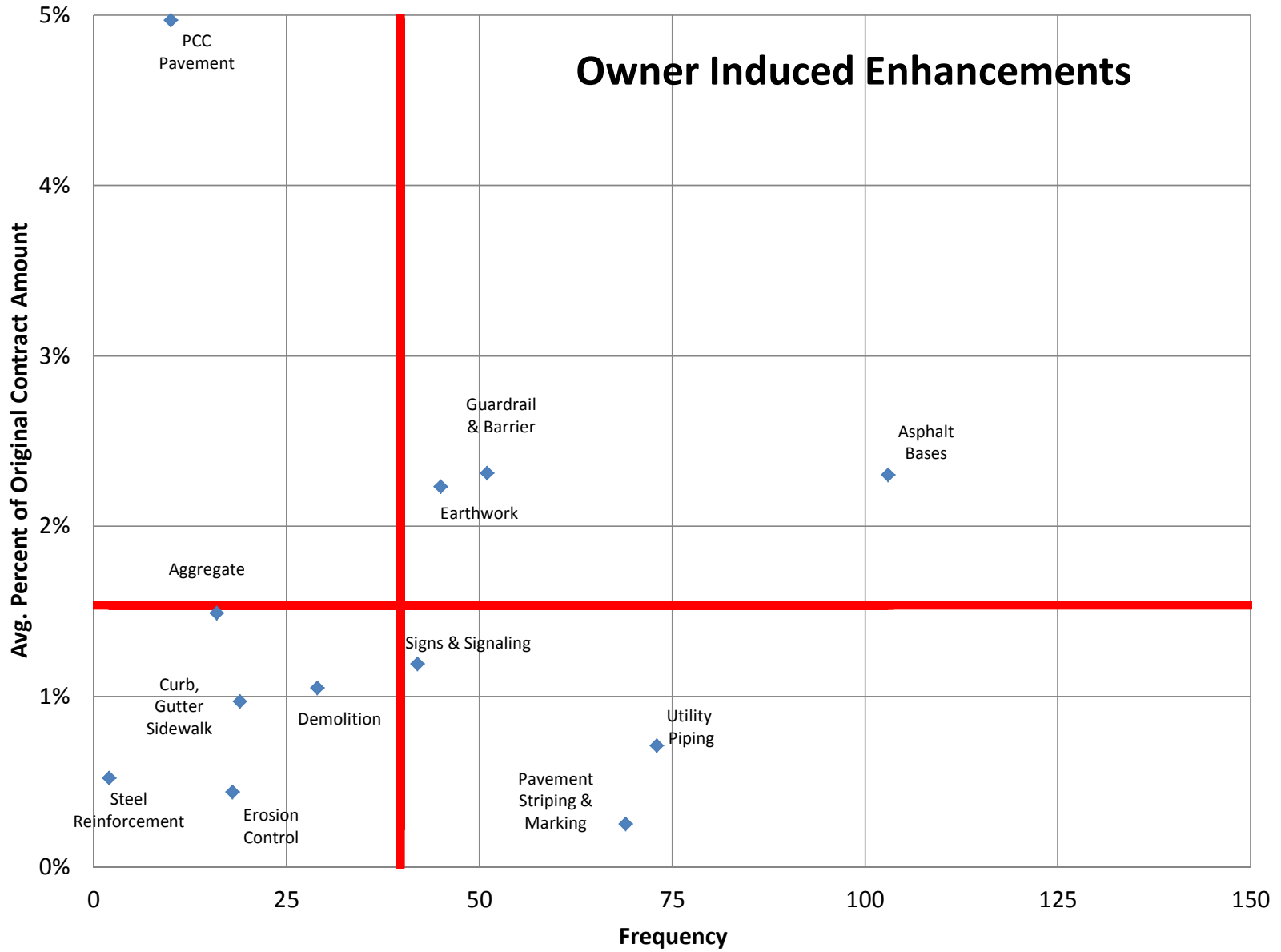


Figure 7: Work Type Risk Analysis Matrix – Owner Induced Enhancement

Figures 5-7 identify several common high risk work categories. Work related to asphalt bases and guard rails and barriers have relatively high frequencies of occurrence and, on average, a higher percent contract cost increase across change order codes than other types of work.

Chapter 2: A Process for Pricing Change Orders

A structured change order pricing process ensures that change orders are priced consistently across the state and ensures that the field personnel time is efficiently utilized in pricing change orders (Figure 7). A process was developed that represents a series of best practices utilized by experienced Section Engineers within the Cabinet, as other state transportation agencies practices, and best practice literature. The following discusses the primary elements of the process.

The Need

The flowchart begins with the identification of the need for a change order. The need may be discovered by either the contractor or the engineer depending upon the situation. It is not uncommon for more experienced engineers to be proactive in the discovery of items requiring a written change order. At this point a consensus may be reached that the issue might not require a change order and can be resolved in some other manner.

Define Scope

The next action involves the engineer and the contractor coming to an agreement on the extent of the work to be included in the change order. The decision as to the extent of the work is important in controlling the scope of the additional work. Lack of clarity in change order scope definition can lead to unnecessary or duplicate work being included in the change order. For example, a change order should not include traffic control costs if adequate traffic control is already in place. As change order work proceeds, having an established list of work to be done and how it will be performed can help to keep prices in check and avoid delays.

A decision must now be made whether the change order is due to a change in scope of the project or if the need is due to a change in quantity. This decision will determine whether a change order can be written quickly or whether a more detailed cost analysis may be needed. If it is determined the change order is due to a change in bid item quantity, unless extenuating circumstances exist (e.g. a significant change in quantity), the contract unit bid price for item should be used to price the change order. It is recommended the engineer independently

verify the quantities presented by the contractor to help avoid excessive cost. After quantities are verified, the change order can be prepared.

If the decision is made there is a change in the scope of the project, the decision arrow leads to an action block for the engineer to request a price from the contractor. At this point a simultaneous action block indicates the engineer should prepare their own initial cost analysis for the change order item(s). The first source of information should be the most recent average unit bid price list found on the Kentucky Transportation Cabinet's website at <http://transportation.ky.gov/Contract/BidHist/>. If the bid item cannot be found in the most recent year, the next most recent year should be viewed to obtain a comparable price for the item(s). This will present an opportunity for the engineer to use professional judgment as to whether using a price from two years prior (or older) would be an acceptable comparison.

Initial Price Analysis

After the contractor submits his price, the engineer reaches another decision. Is the contractor's submitted price consistent with the engineer's initial cost analysis using the average unit price list AND is it acceptable to the engineer? Past practice within the Cabinet has been to accept unit prices for change order work that fall with $\pm 10\%$ of the average unit bid price. However, the engineer still must use their judgement to determine whether this price is acceptable. For example, the engineer may feel a higher unit price is justified due to the location of the work or due to the small quantities. If the contractor submitted change order price is acceptable then the engineer will prepare the change order. If however the engineer decides the price is not acceptable, the next step is a more detailed cost analysis.

Detailed Price Analysis

At this point the engineer should develop a more detailed cost analysis that will provide a more rigorous cost analysis to compare to the contractor's price. The action box has three options presented for developing a more detailed price. The engineer should not feel constrained by the order of analysis presented in the flowchart but should select the analyses most appropriate for the given situation. The first option is to research relevant unit prices on identical work items in the immediate area using resources such as current and past KTC

contracts, external contracts, and equipment rental businesses. It is also recommended to compare pricing between multiple contractors in the same area. Checking pricing in the immediate area allows the engineer to compare pricing relevant to where the contractor would assumedly be procuring materials, labor and equipment.

The second option is to research prices for similar change orders using Site Manager, the Cabinet's construction management software. This software allows access to other contracts throughout the state and allows the engineer look for similar items to compare costs. The engineer can look for contracts in surrounding regions or look in regions that are not as close to compare variations in the pricing.

The third option listed in the block would be for the engineer to consult with staff in the KTC offices in Frankfort. Central office support staff is available to assist in pricing change orders when engineers require additional resources not available to field personnel.

Detailed Price Examination

Once the engineer has been able to develop an estimate using one or more of the proceeding options, the flowchart proceeds to another decision: is the contractor's price justified by the more detailed cost analysis? If the engineer decides at this point the contractor's price is fair and is acceptable, then they proceed to prepare the change order. If the price is still judged to be unacceptable by the engineer, the engineer should request a detailed price justification from the contractor. This detail should include the breakdown of materials, labor and equipment. After receiving the detailed price justification the engineer again needs to decide if the price justification is reasonable. If the decision is yes, then the change order is written. If the decision is that the price is still not acceptable, the engineer must decide if he can successfully negotiate with the contractor and agree upon a price. If the engineer can successfully come to an agreement upon the change order price, then the change order is prepared using the negotiated price. If a price cannot be negotiated, the change order will need to be executed under a force account agreement. Due to the resource requirements implementing force accounts for change orders should be a last resort.

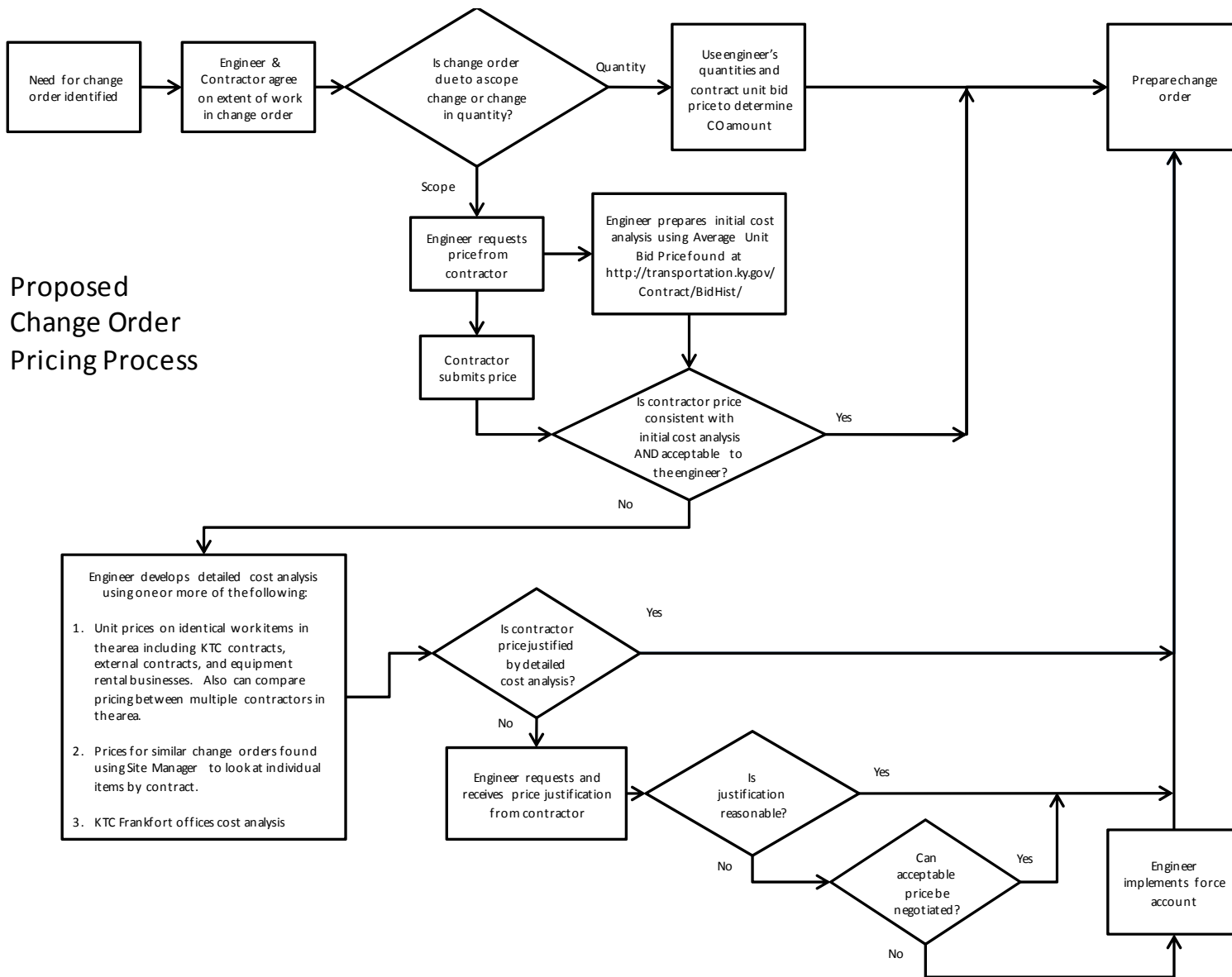


Figure 7: Change Order Pricing Process

Chapter 3 – Summary

This research identified the following three change order codes as providing the greatest change order risk on Cabinet projects:

- Contract Omission;
- Contract Item Overrun; and
- Owner Induced Enhancement

While every project is unique, many of the change orders categorized under these codes are within the Cabinet’s control. Improved project planning during the design phase can reduce the risk posed by change orders. To maximize the impact of limited initial planning resources the current work indicates these planning resources should be focused on project elements related to asphalt bases and guard rails and barriers.

While improved project planning can minimize change orders it is unlikely that change orders can be completely eliminated. Therefore, it is important to have efficient procedures in place to process and price change orders. The change order pricing process presented here is intended to offer a formal pricing process for Cabinet change orders to ensure consistent change order pricing practices across the state. This process should be useful to experienced Cabinet personnel, but this process can also be used as a training tool for personnel less experienced in pricing change orders.

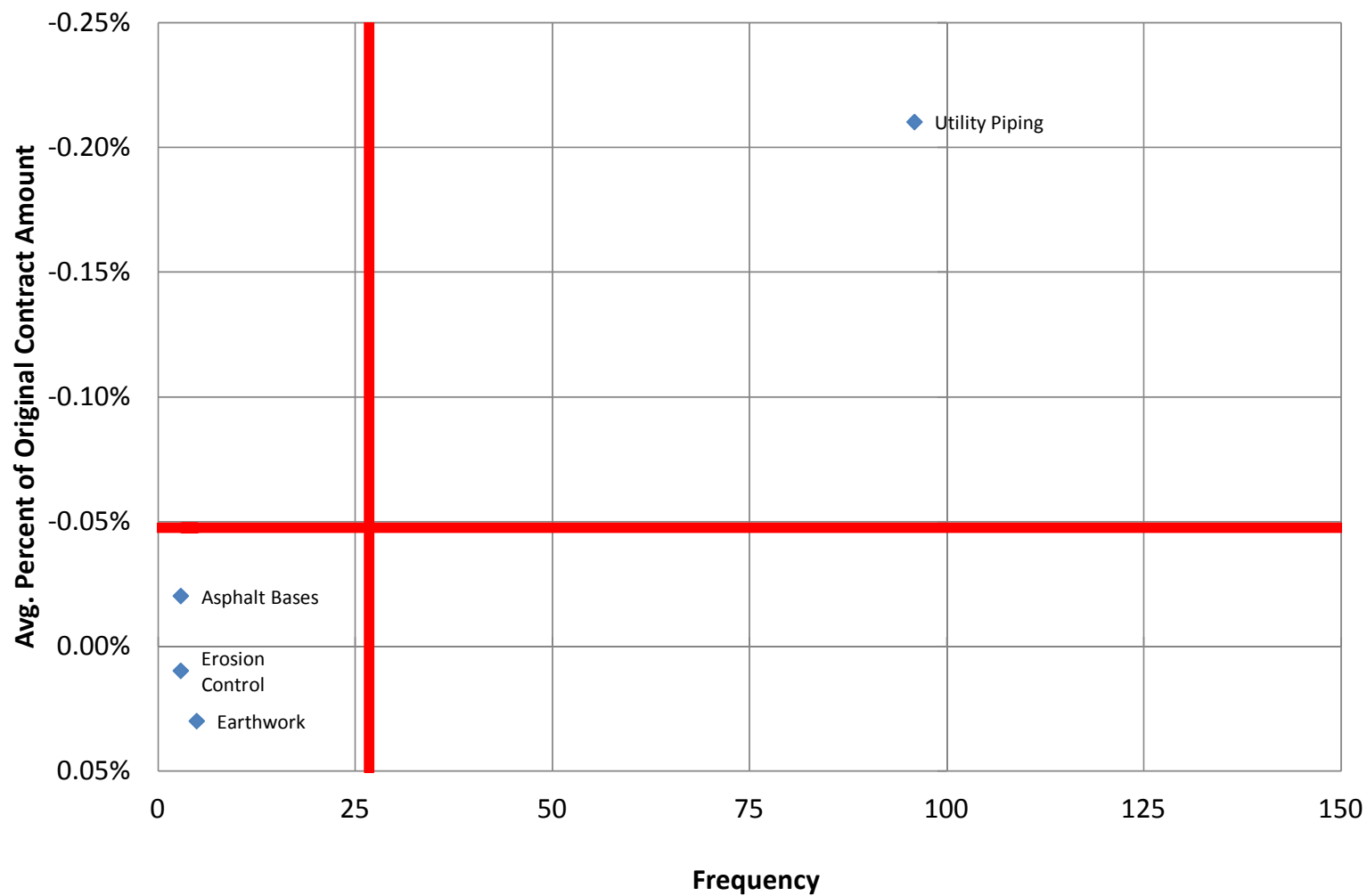
Appendix

Work Type Analysis Matrix – Utility Issues

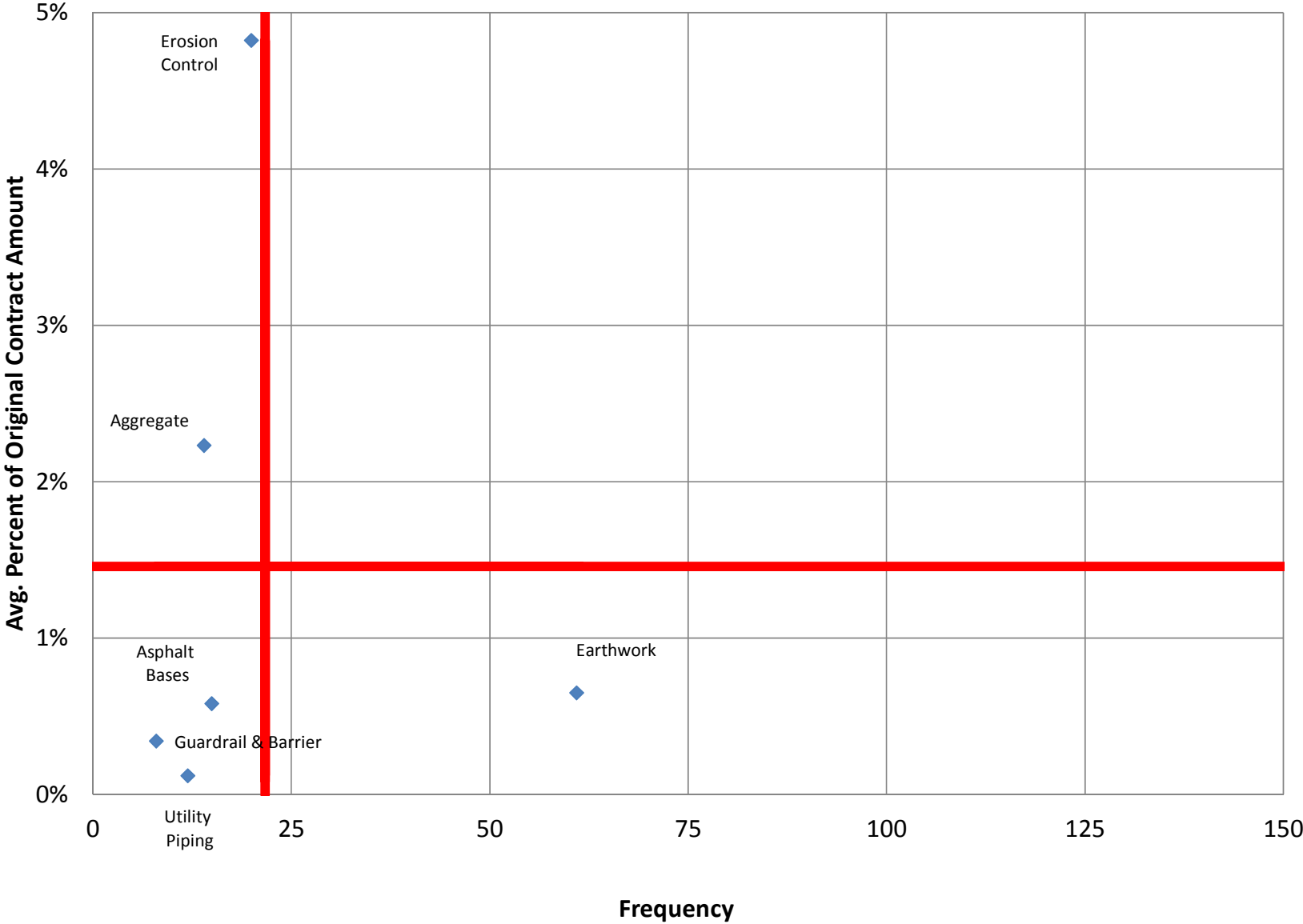
Work Type Analysis Matrix – Geotechnical Issues

Work Type Analysis Matrix – Contract Item Underrun

Work Type Analysis Matrix – Utility Issues



Work Type Analysis Matrix – Geotechnical Issues



Work Type Analysis Matrix – Contract Item Underrun

