California Multi-Agency CIP Benchmarking Study

Engineering Report

CIP Benchmarking Study






Department of PUBLICWORKS
CITY OF SACRAMENTO

CITY OF SAN JOSE
CAPITAL OF SILICON VALLEY

CITY OF LONG BEACH

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CHAPTER 1 Executive Summary

A. INTRODUCTION

Over the next three years, six of the largest cities in California are expected to award nearly $6 billion dollars in public works infrastructure construction contracts. These municipalities are building roads and transportation systems, sewer and water infrastructure, municipal facilities, libraries, parks and recreation facilities, animal shelters, fire stations, bridges, seismic retrofits, bikeways, storm drains, and other facilities.

While $6 billion dollars for public works improvements is a significant amount, it does not represent the entire infrastructure cost. There are additional, significant costs - over and above construction - to deliver these projects. The costs associated with the project delivery process - planning, design, environmental documentation, value engineering, permits, construction management and startup - are influenced by many factors such as project size and complexity, new construction vs. rehabilitation, internal organization, project prioritization, clear guidelines, and more.

With all of this construction on tap in California, would it be possible - and beneficial - for cities to collaborate, pool their knowledge and experience on these cost-influencing factors, then benchmark their project delivery processes so they can learn from each other's successes, while keeping project delivery costs to a minimum? The answer found in this report is a definite yes.

In October 2001, the City of Los Angeles, Department of Public Works, Bureau of Engineering initiated a benchmarking study through the cooperative effort of individuals responsible for the development and implementation of Capital Improvement Projects (CIP) in six of the larger California cities. The objective of this study was to provide a general analysis of the efficiency of capital project delivery systems within various agencies in California, based on the observed performance and the processes implemented over the last five years.

The California Multi-Agency CIP Benchmarking Study is the beginning of a planned cooperative and continuous benchmarking study that may eventually include other agencies throughout the State of California. The following agencies participated in the first phase of the study:

- City of Long Beach, Department of Public Works
- City of Los Angeles, Department of Public Works/Bureau of Engineering
- City of Sacramento, Department of Public Works
- City of San Diego, Engineering & Capital Projects
- City & County of San Francisco, Department of Public Works / Bureau of Engineering / Bureau of Architecture / Bureau of Construction Management
- City of San Jose, Department of Public Works

This benchmarking study report is the result of the first year of collaboration among these six member agencies. The study examined process benchmarks, focusing on business processes (the approach to managing Capital Improvement Projects (CIP) in the individual agencies). The study also examined performance benchmarks - consisting of developing comparative data on costs and schedules of projects from the participating agencies.

The team identified 15 common best management practices (Table A) currently used by virtually all six participating agencies. The six agencies identified 24 recommended best management practices (Table B) that should be implemented to deliver high quality projects faster and at lower cost, based upon an analysis of process benchmarking.

This is intended to be a continuing study, and future phases are expected to refine and improve the conclusions and recommendations as additional project data is provided. An annual update of this report is planned.

B. STUDY METHODOLOGY

This study was conducted in four stages.

1. General information was collected from the agencies during the first stage. The study team identified general criteria for performance and process data collection (project categories and phases, performance curves, and process categorization) based on information availability and agencies' expectations.
2. The focus of the second stage was the collection and analysis of data on the processes used to deliver capital projects. Ninety-eight incremental processes related to project delivery were identified and evaluated.
3. The third stage of the study emphasized performance data collection (primarily costs and schedules), data compilation into the project database, and development and optimization of performance curves (graphs that relate the cost of construction to the various costs of project delivery). Performance data on a total of 239 projects with a total construction value of over $490 million was used to develop the comparative performance benchmarking curves (graphs) for municipal facilities, streets, and pipe systems showing percentage of design, construction management, change orders, and overall project delivery costs, compared to total construction costs.
4. The fourth stage of the study consisted of review and discussion of performance and process benchmarking outcomes.

C. CONCLUSIONS OF PROCESS BENCHMARKING: BEST MANAGEMENT PRACTICES

The gathering of executive level technical staff from six major cities to share information about costs and openly discuss the effectiveness of their capital project delivery methods is practically unprecedented. As noted above, ninety-eight processes associated with the effective delivery of capital projects were identified, discussed, and evaluated by the agency representatives in an effort to develop the ability to benchmark capital improvement projects in the industry.

The process benchmarking exercise resulted in the identification of 15 best practices currently being employed by most agencies. The participating agencies also agreed on an additional 24 best management that are recommended to improve project delivery. See Tables A and B below.

Table A – Common Best Management Practices

Process Category	Ref.*	Common Best Management Practices
Planning	1.a.	Capital projects are well defined with respect to scope and budget at the end of the planning phase
	1.f.	There is a Master Schedule attached to the CIP that identifies start and finish dates for projects
	1.i.	Projects shown on a Geographical Information System
Design	2.d.	Designers are required to provide a work plan or design schedule prior to design start
	2.g.	Designs are done on 2D CAD systems
Quality Assurance / Quality Control	3.I.d.	Agency uses standard forms for RFI's, Change Orders, Pay Applications, Field Clarifications, Minutes of Meetings, etc.
	3.III.g.	Inspectors are trained and, when required, certified
Construction Management	4.I.f.	A change order contingency is set aside at the start of the project.
	4.I.d.	A formal change order process is in place, which defines all forms and methods necessary to finalize change orders
Project Management	5.1.d.	A Project Manager is assigned to every project
	5.1.e.	Project Manager has "cradle to grave" involvement
	5.III.a.	A standard Project Control System has been adopted by the Agency and is in use on all projects
Consultant Selection and Use	6.h.	The consultant selection process is qualification based
	6.c.	A Standard Consultant contract is included in the RFQ/RFP
	6.f.	An Annual RFQ/RFP solicitation is used to develop an on-call list of pre-approved consultants

* Reference to the corresponding question in the process questionnaire in Appendix C (pp. C-2 - C-7)

Table B – Recommended Best Management Practices

Process Category	Ref.*	Recommended Best Management Practices
Planning	1.b.	Complete Feasibility Studies on projects prior to defining budget and scope
	1.d.	Have a Board/Council project prioritization system
	1.e.	Provide resource loading for projects listed in the CIP for design and construction
Design	2.f.	Define requirements for reliability, maintenance, and operation prior to design start
	2.b.	Provide a clear, precise scope to designers prior to design start
	2.i.	Adapt successful designs to project sites, whenever possible (e.g. fire stations, gymnasiums, etc.)
	N/A	Develop and use Green Buildings Standards
Quality Assurance / Quality Control	3.III.a.	Use a formal Quality Management System
	3.I.a.	Develop and use a standardized Project Delivery Manual
	3.II.b.	Perform a formal Value Engineering Study for projects larger than $1,000,000
	3.III.b.	Perform and use Post Project Reviews for lessons learned
Construction Management	4.IV.a.	Involve the Construction Management Team before completion of design
	4.I.g.	Set aside 15% for construction change order contingency
	4.I.a.	Delegate authority to the City Engineer / Public Works Director to approve change orders to the contingency amount
	4.I.m.	Classify types of changes
	4.II.a.	Include a formal Dispute Resolution Procedure in all contract agreements
	4.III.a.	Use a team building process for projects greater than $5 million.
	N/A	Delegate authority for Change Order approval to the departments, in order to reduce paperwork
	N/A	Establish award limits for construction to support award by the director without a Board approval
	N/A	Establish a pre-qualification process for contractors for large complex projects
Project Management	5.I.f.	Assign a client representative to every project
	5.II.a	Provide formal training for Project Managers on a regular basis
Consultant Selection and Use	6.e.	Delegate authority to the PW Director/City Engineer to approve consultant contracts under $250,000, when a formal RFP selection process is used
	6.g.	Implement and use a consultant rating system that identifies quality of consultant performance

*Reference to the corresponding question in the process questionnaire in Appendix C (pp. C-2 - C-7). N/A indicates that the recommended best management practice was the outcome of the team discussion and did not appear on the process questionnaire.

D. CONCLUSIONS OF PERFORMANCE BENCHMARKING

The following performance benchmarking conclusions were based on an analysis of project data provided by the six participating cities:

- The percentage of design costs decreased with the increasing size of the projects. For 210 projects with total construction cost of $100,000 or more[1] (out of the total 239 projects), design costs vary between 0.6% and 78% of total construction costs, with an average of 18%.
- The construction management costs as a percentage of total construction costs decreased as the total construction costs increased. For 210 projects larger than $100,000 total construction cost have construction management costs between 0.2% and 48%, averaging 14% of total construction cost.
- Based on the performance data, total project delivery cost (total design cost and construction management cost), for 210 projects larger than $100,000 total construction cost, ran between 5% and 111% of the total construction cost with an average of 32%.

Benchmarking related to the costs of change orders and project durations was harder to quantify because several factors greatly influenced these two project delivery areas. For example, some cities directed contractors to make changes to the project using the change order contingency (owner-directed), which could drive up change order costs dramatically compared to cities that used change orders only for changed conditions and design changes.

1 It is common for projects smaller than $100,000 to have delivery costs larger than 100% of total construction cost. Therefore, these projects play as outliers and are not accounted for in these estimates. The outliers, however, are not eliminated in the performance graphs, as discussed in chapter 7.

Regarding Project duration, no correlation was identified during the performance benchmarking effort between total construction cost and total project duration. This may be due to inherent differences in the business processes during the planning, bid and award, and closeout phases.

Great variability exists in these two categories, and as a result the information contained in this report about change orders and project duration is for information purposes only.

Table C follows and shows project delivery costs for Capital Improvement Projects with known construction values. As more data is collected, Table C can be improved and the statistical validity of the models will be enhanced. The conclusions of the performance study may then be used as approximate "guidelines" to predict associated costs for a Capital Improvement Project.

E. LESSONS LEARNED

The study team succeeded in collecting and graphing performance data and identifying and targeting recommended best management practices for implementation. As a result of meetings, discussions, review and analysis of the performance data trends and outcomes of process benchmarking, the following lessons were learned:

- Best management practices were intuitively identified after review, discussion, and evaluation of current project management and delivery processes used by the agencies. The project team consisted of senior managers from California's largest cities, and collectively, represented over 300 years of experience in managing public works projects. The collaboration and information sharing allowed this group to extract the 15 practices that were common to all of the agencies, and to identify and recommend 24 other best management practices that would help agencies improve their project delivery efforts.

- The performance benchmarking database provided a tool that could be used to compare any one agency to the industry. This tool, augmented by additional data, could also be used to predict resource requirements to deliver projects and to estimate change orders and total duration of a construction project of given type, size, and classification.
- Projects smaller than $100,000 and greater than $10,000,000 significantly influence the trend of the regression curves portrayed within this phase of the study. However, the regression curves on some of the projects approached zero within the range of the construction values of the projects studied. This condition is unrealistic and additional data is required to improve the curves at future phases of this study.
- During the performance benchmarking, the availability of data was identified and differences among the agencies noted. Each participating agency has a budgeting/accounting process that is unique to that agency, which made it very difficult to break down the costs of project delivery in a standardized way. It would be desirable to know and be able to compare the costs of smaller, more succinct categories such as "planning", "predesign", "design", "bid & award", and others, but because of the variability of cost accounting, this is currently impossible. In addition, some of the cities participating in this study reported that certain project delivery functions (e.g., planning) are done outside of the public works/engineering departments, making it even more difficult to compare smaller components of the costs of project delivery. Therefore, the study compared broad design and construction management costs. (The study team agreed to review budgeting and accounting procedures and recommend modifications/standards that would improve future phases of the study.)

*Table C – CIP Delivery Costs**

PROJECT TYPE CLASSIFICATION	Total Construction Cost (TCC)	Design Cost / TCC	Construction Management Cost / TCC	Project Delivery Cost / TCC
Municipal Facilities	**TCC< $0.5M**	**35% - 50%**	**17% - 19%**	**48% - 55%**
	$0.5M<TCC<$ 3M	**25% - 44%**	**12% - 15%**	**35% - 42%**
	TCC> $3M	**19% - 37%**	**9% - 12%**	**28% - 35%**
Libraries	TCC< $0.5M	38% - 43%	22% - 27%	
	$0.5M<TCC<$ 3M	26% - 32%	17% - 21%	
	TCC> $3M	20% - 24%	11% - 16%	
Police/ Fire Station	TCC< $0.5M	23% - 28%	12% - 14%	
	$0.5M<TCC<$ 3M	19% - 23%	10% - 12%	
	TCC> $3M	16% - 21%	8% - 11%	
Community Building / Recreation Center / Children Center / Gymnasium	TCC< $0.5M	38% - 43%	16% - 18%	
	$0.5M<TCC<$ 3M	28% - 32%	11% - 13%	
	TCC> $3M	20% - 25%	8% - 11%	
Streets	**TCC< $0.5M**	**30% - 40%**	**20% - 28%**	**45% - 61%**
	$0.5M<TCC<$ 3M	**19% - 35%**	**12% - 20%**	**32% - 47%**
	TCC> $3M	**19% - 35%**	**N/A**	**N/A**
Widening / New / Grade Separation	TCC< $0.5M	28% - 32%	12% - 17%	
	$0.5M<TCC<$ 3M	20% - 25%	12% - 17%	
	TCC> $3M	16% - 21%	12% - 17%	
Bridge / Retrofit / Seismic	TCC< $0.5M	60% - 80%	18% - 23%	
	$0.5M<TCC<$ 3M	32% - 55%	14% - 19%	
	TCC> $3M	19% - 40%	12% - 17%	
Renovation / Resurfacing	TCC< $0.5M	12% - 18%	20% - 25%	
	$0.5M<TCC<$ 3M	11% - 17%	13% - 18%	
	TCC> $3M	11% - 17%	N/A	
Bike / Pedestrian / Curb Ramps	TCC< $0.5M	22% - 40%	22%-35%	
	$0.5M<TCC<$ 3M	18% - 35%	5% - 10%	
	TCC> $3M	N/A	N/A	
Signals	TCC< $0.5M	18% - 25%	20% - 28%	
	$0.5M<TCC<$ 3M	15% - 22%	19% - 25%	
	TCC> $3M	N/A	N/A	
Pipes	**TCC< $0.5M**	**35% - 42%**	**17% - 22%**	**45% - 62%**
	$0.5M<TCC<$ 3M	**19% - 35%**	**10% - 15%**	**30% - 45%**
	TCC> $3M	**19% - 35%**	**N/A**	**N/A**
Gravity System (Storm Drains, Sewers)	TCC< $0.5M	35% - 50%	17% - 22%	
	$0.5M<TCC<$ 3M	20% - 35%	12% - 18%	
	TCC> $3M	N/A	N/A	
Pressure Systems	TCC< $0.5M	18% - 23%	16% - 19%	
	$0.5M<TCC<$ 3M	14%-17%	13% - 16%	
	TCC> $3M	N/A	N/A	
Pump Station	TCC< $0.5M	N/A	N/A	
	$0.5M<TCC<$ 3M	15% - 17%	17% - 19%	
	TCC> $3M	16% - 18%	11% - 14%	

* The values in this table provide an overall summary of the performance benchmarking results. Caution is necessary in using this information as a predictive tool. Additional data, at future phases of this study, will significantly improve this table and may provide a basis for more accurate forecasting.

Chapter 2

Introduction






CHAPTER 2

Introduction

A. PROJECT HISTORY

The City of Los Angeles, Department of Public Works/Bureau of Engineering recognized an opportunity to improve the efficiency of delivering Capital Improvement Projects in the state of California. As a result, the City initiated the *California Multi-Agency CIP Benchmarking Study* with five other California municipal agencies in October of 2001. These agencies would take the unprecedented step of sharing costs and procedures related to the delivery of their most significant projects implemented in the previous five years. This report summarizes the study methodology, the outcomes, and the lessons learned from the benchmarking study.

B. STUDY OBJECTIVE

The purpose of the study is to provide a general analysis and benchmarking of how capital improvement projects are delivered by several public agencies within California. The study is based on observed and documented performance on projects completed within the last five years and current CIP delivery processes.

The participating agencies entered into the study with the intent of making improvements, not comparisons. The agencies performed non-competitive analyses of their own projects and processes in order to contribute to the development of benchmarks based on industry trends. In order to preserve this non-competitive spirit no projects are identified by name in this document and agencies are referred to generically (Agency A, etc.), when anonymity is appropriate.

The following were identified by the participating agencies as the most desirable outcomes of this study:

- Initiation of a continuous forum for communication to enable agency representatives to network with one another
- A learning experience for all agencies to understand each other's processes for managing Capital Improvement Projects, through brainstorming sessions and discussions
- A "Predictive Tool": a basis to estimate Capital Improvement Projects delivery costs in the future
- A "Comparative Tool": a basis for every agency to compare their performance against general industry trends
- A list of "best management practices" recommended as those processes that are the most effective in producing efficient project delivery
- A list of "best management practices" that are most common among the participating agencies.
- Initiation of a continuous benchmarking effort, to include more projects, as they are completed, and more agencies

C. PARTICIPANTS

The City of Los Angeles, Department of Public Works, Bureau of Engineering sponsored a **study team** that was responsible for logistics, management, and execution of this benchmarking study. The City invited several other agencies within California to participate in this study. The agencies below elected to participate in the study (**project team**) after reviewing the October 2001 briefing paper provided by Los Angeles (Appendix A-I, page A-3).

- City of Long Beach, Department of Public Works
- City of Los Angeles, Department of Public Works/Bureau of Engineering
- City of Sacramento, Department of Public Works
- City of San Diego, Engineering & Capital Projects
- City and County of San Francisco, Department of Public Works / Bureau of Engineering / Bureau of Architecture / Bureau of Construction Management
- City of San Jose, Department of Public Works

During nine months of meetings, the project team (composed of the participating agencies) and the study team planned and implemented the benchmarking study.

D. REPORT STRUCTURE

This report is organized as follows:

- This introductory chapter (Chapter 2) provides a brief explanation of the project history, objectives, and project participants.
- Chapter 3 provides a profile of each of the participating agencies, including descriptions of their city and agency structure, and their capital improvement programs for FY 2001-02 through FY 2003-04.
- Chapter 4 explains the study methodology, the selection of projects, and the basis of comparison (cost versus hours). Chapter 4 also provides an introduction to the benchmarking effort that is broken down into two stages: **process benchmarking** and **performance benchmarking**.

  Process benchmarking focuses on business processes—the approach to managing the delivery of CIP projects in the individual agencies.

  Performance benchmarking consists of the development of the projects' comparative cost and schedule data. These benchmarks are discussed in detail in the following chapters.
- Common and recommended best management practices, based on process benchmarking, are identified in Chapter 5 and process study findings are discussed. The participating agencies provided extensive data about their delivery processes by responding to a questionnaire developed by the project team. This questionnaire and its results are described in Chapter 5 and Appendix C.
- Chapter 6 is on performance benchmarking and explains the basis for project selection and data definition as appropriate for performance benchmarking. Chapter 6 also discusses design of the performance questionnaire and the agencies' responses. Performance graphs that are generated from the project database are also reviewed and discussed within Chapter 6.
- Chapter 7 gives conclusions and recommendations based on the process benchmarking results in Chapter 5 and performance

Chapter 3

Participating Agencies






CHAPTER 3 Participating Agencies

A. INTRODUCTION

This section of the report profiles the six agencies that participated in the *California Multi-Agency CIP Benchmarking Study*.

Each agency's summary is structured as follows:

1. City Description
    a. Size, population, website
    b. Governmental structure: mayor, city manager, council, board, etc.
2. Agency Description
    a. Organizational structure and disciplines, number of employees
    b. Responsibilities and stewardships
    c. Operating budget for Fiscal Year 2001 – 2002, capacity and funding sources
    d. Work processes and project management approach
3. FY 01-02 through FY 03-04 capital improvement projects (description, number, and size). A table that describes the in-house project delivery services for the participating agencies (Table D) follows the summaries. A "Fact Sheet" (Table E), provides an overview of all six participating agencies.

A review of the practices of the participating agencies yielded some very interesting information:

- The agencies' operations and approaches to project delivery are strikingly similar.
- All have a strong management approach with a project manager responsible for budgets, schedules, and quality management from the beginning of a project to the end.
- The six participating cities expect to award nearly $6 billion in public works capital improvement project contracts within the next three years.

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B. DESCRIPTION OF PARTICIPATING AGENCIES

I. City of Los Angeles

POPULATION	3,694,820
AREA	469 square miles
WEBSITE ADDRESS	http://eng.lacity.org

FORM OF GOVERNMENT

Los Angeles has a Mayor-Council-Commission form of government as provided by the Free holders' Charter effective July 1, 1925. The current City Charter became effective on July 1, 2000. The people elect the Mayor, City Controller, and City Attorney every four years. Fifteen City Council members representing fifteen districts are elected to four-year terms. Members of commissions are appointed by the Mayor, subject to the approval of the City Council. With few exceptions, all other officials and employees of the City are subject to the civil service provisions of the Charter.

DEPARTMENT OF PUBLIC WORKS – Bureau of Engineering

The Bureau of Engineering is responsible for the design and construction of all public facilities, streets, sewers, and storm drains. The Bureau is also responsible for the engineering features and standards of all privately developed subdivisions, tracts, and construction of public improvements in the City's right-of-way. The head of the Bureau is the City Engineer.

Bureau personnel work on the expansion and modernization of over 7,400 miles of streets, 1,000 miles of storm drains, 6,500 miles of sewer lines, the design and construction of police and fire stations, libraries, parking structures, wastewater treatment plants, bridges, and other public works projects. Recent past projects include the Convention Center Expansion, renovation of the Central Library, and the seismic retrofit of City Hall.

The Bureau employs over 1,000 employees in many different disciplines including engineering, architecture, surveying, drafting, real estate, environmental, and construction management.

PROJECT MANAGEMENT/DELIVERY

The Bureau uses a strong project management delivery system in which projects are assigned to a project manager who is responsible for the budget and schedule from planning through project closeout. Project funding is usually generated from special funds including bonds, user fees, and grants. The 33 groups/divisions within the Bureau use a design-bid-construct project delivery system with the objective of using in-house resources to provide design and construction management. Consultants are used to supplement in-house resources when necessary.

CONSTRUCTION CONTRACTS/CAPITAL IMPROVEMENT PROGRAM

Construction contracts to be awarded for Fiscal Year 2001-02 through Fiscal Year 2003-04 include:

Program	Total Projects	Total Cost
Animal Bond	8	$84,000,000
Bridge Improvement Program	64	$158,000,000
Fire Bond	21	$201,000,000
Library Bond	47	$90,000,000
Municipal Facilities	32	$94,000,000
Recreation Facilities	28	$91,000,000
Seismic Bond	6	$65,000,000
Storm-water Program	61	$23,000,000
Street Program	42	$103,000,000
Wastewater Program	160	$490,000,000
Zoo Bond	6	$45,000,000
Total	**475**	**$1,444,000,000**

II. City of Long Beach

POPULATION	461,522
AREA	50 square miles
WEBSITE ADDRESS	http://www.ci.long-beach.ca.us/pw

FORM OF GOVERNMENT

Long Beach has a Council-Manager form of government as provided by Charter effective July 5, 1921. The current City Charter became effective in 1980. Mayor, City Auditor, City Prosecutor, and City Attorney elected by the people every four years. Nine City Council members representing nine districts are elected by the people to four-year terms. Members of commissions are appointed by the Mayor, subject to the approval of the City Council. Most other officials and employees of the City are subject to the civil service provisions of the Charter.

DEPARTMENT OF PUBLIC WORKS – Bureau of Engineering

The Bureau of Engineering is responsible for the design and construction of all public facilities, streets, sewers, and storm drains. The Bureau is also responsible for the engineering features and standards of all privately developed subdivisions, tracts, and construction of public improvements in the City's right-of-way. The head of the Bureau is the City Engineer.

Bureau personnel work on the expansion and modernization of over 860 miles of streets, the design and construction of libraries, airport facilities, parking structures, bridge rehabilitations, and other public works projects. Recent past projects include the Emergency Communications and Operations Center, Lakewood Boulevard Widening, and the seismic retrofit of the historic Rancho Los Cerritos.

The Bureau employs over 90 employees in many different disciplines including engineering, architecture, surveying, drafting, and construction management.

PROJECT MANAGEMENT/DELIVERY

The Bureau is initiating a strong project management delivery system in which the projects are assigned to a project manager who is responsible for the budget and schedule from planning through project closeout. Project funding is usually generated from a variety of funding sources. The three groups/divisions within the Bureau have a philosophical approach to a design-bid-build project delivery system with the objective of using a mix of in-house and consultant contracts to provide design and construction management.

CONSTRUCTION CONTRACTS/CAPITAL IMPROVEMENT PROGRAM

Construction contracts to be awarded for Fiscal Year 2001-02 through Fiscal Year 2003-04:

Program	Total Projects	Total Cost
Airport	10	$62,000,000
Community Development	5	$27,000,000
Parks, Recreation and Marine	27	$8,000,000
Public Facilities	26	$71,000,000
Public Thoroughfares	21	$55,000,000
Storm Drains	1	$2,000,000
Tidelands	23	$39,000,000
Total	**113**	**$264,000,000**

III. City of Sacramento

POPULATION	418,700
AREA	98 square miles
WEBSITE ADDRESS	http://www.pw.sacramento.com

FORM OF GOVERNMENT

Sacramento's City Council-City Manager form of government was adopted in 1920. The City Charter was also adopted in 1920. The City Council consists of a Mayor elected by the people and Council members, elected to represent the eight separate council districts in the City. Elected members serve four-year terms and elections are staggered every two years in even numbered years. Members of Boards and Commissions are appointed by the Mayor, subject to the approval of the City Council. The City Manager, City Treasurer, City Attorney, and City Clerk are appointed by the City Council with all other exempt managers appointed by the City Manager. All other officials and employees of the City are subject to the civil service provisions of the Charter.

DEPARTMENT OF PUBLIC WORKS – Project Delivery Division

The Project Delivery Division is responsible for the design and construction of public buildings, facilities, and transportation projects. The division is managed by the Project Delivery Manager, who reports to the Director of Public Works.

Division personnel work on the expansion and modernization of 1,290 miles of streets, the design and construction of police and fire stations, libraries, parking structures, community centers, bridges, freeway interchanges, and other public works projects. Recent past and current projects include the Joe Serna, Jr. Environmental Protection Agency Headquarters Building, South Natomas Community Center and Library, the extension of Seventh Street, and the Arena Boulevard Interchange at Interstate 5.

The Division has about 100 employees in many different disciplines including civil engineering, electrical engineering, mechanical engineering, architecture, surveying, drafting, and construction management. Accounting and administrative staff provide support.

PROJECT MANAGEMENT/DELIVERY

The Division uses a strong project management delivery system in which the projects are assigned to a project manager who is responsible for the budget and schedule. Projects are managed by the Funding & Priorities section during the planning phase. When the projects have been fully scoped and funded, other project managers are assigned that are responsible from design through construction and project closeout. Funding for projects is usually generated from transportation funds, grants, fees, bonds, redevelopment funds, and the City's General Fund. The Division uses private consultants to supplement in-house resources to provide design and construction management services.

CONSTRUCTION CONTRACTS/CAPITAL IMPROVEMENT PROGRAM

Construction contracts to be awarded for Fiscal Year 2001-02 through Fiscal Year 2003-04:

Program	Total Projects	Total Cost
Public Facilities	150	$180,000,000
Transportation	90	$200,000,000
Total	**240**	**$380,000,000**

IV. City of San Diego

POPULATION	**1,277,168**
AREA	**342 square miles**
WEBSITE ADDRESS	**http://www.sandiego.gov**

FORM OF GOVERNMENT

The City of San Diego, the second largest city in the state and the seventh largest city in the nation, was incorporated on March 27, 1850. In 1931 the Charter by the Board of Freeholder's was adopted by the voters and, although it has undergone many modifications, is still in effect today. The City utilizes a Mayor-Council-Manager form of government with only the Mayor and City Attorney elected city-wide by the people every four years. Eight City Council members are elected by the people in their respective districts to serve four-year terms. The Council selects a City Manager who is responsible for the administration of most City departments. Officials and employees of the City are subject to the civil service provisions of the Charter, with the exception of unclassified management and a few un-represented employee classifications.

ENGINEERING AND CAPITAL PROJECTS DEPARTMENT

The Engineering and Capital Projects (E&CP) Department provides capital improvement project (CIP) services for the various operating departments throughout the City, including the Transportation Department, Fire, Park & Recreation, and others. In this role, the E&CP Department is responsible for the design, project management, and construction management for a vast majority of public facility capital improvement projects (CIP). This work includes such projects as streets, bridges, bikeways, storm drains, and municipal buildings as well as the replacement of water and sewer mains throughout the City.

The Department is split into five divisions with three project management/design divisions (including Transportation & Drainage Design, Water & Wastewater Facilities, and Public Buildings & Parks) and two support divisions (Field Division and Administration (Contract Services). The Director of the E&CP Department is the City Engineer. The E&CP employs over 450 employees[1] in many different disciplines under this structure, including engineering, architecture, surveying, drafting, environmental, materials testing, and construction management.

The E&CP Department staff, on behalf of the client departments, is responsible for the expansion and modernization of over 3,820 miles of streets and alleys, 769 miles of storm drains and channels, approximately 2,900 miles of sewer mains, and 3,139 miles of water mains as well as all the fire, library, and park facilities. Recent major projects include the Convention Center Expansion, expansion of Qualcomm Stadium, the construction of State Route 56 and the new downtown Ballpark.

[1] As of FY02, the total number of full-time positions is 415, as reflected in the Fact Sheet. The FY03 budget includes some new positions that would move the estimate over 450 positions.

PROJECT MANAGEMENT/DELIVERY

E&CP uses a "central point of contact" project delivery system in which the projects are assigned to a project manager within a design division who is then responsible for the management, budget, and schedule from the beginning of design phase (in some cases planning) through project close-out. Engineering is performed by either in-house staff from within the project manager's division or through the use of outside consultants, depending on the complexity and availability of resources.

Most projects make use of in-house resources for design services. The project manager also utilizes the resources of the supporting divisions' staff for such services as surveys, contract procurement, construction management, and inspection. Funding is initially identified for a project by the client department during the planning process, and is generated from a variety of sources from tax revenue to special funds including bonds, user fees, and grants. The three project management/design divisions within the department most commonly use the design-bid-build project delivery system but are beginning to utilize alternative forms of project delivery including design-build methods and task order contracts.

CONSTRUCTION CONTRACTS/CAPITAL IMPROVEMENTS PROGRAM

Capital Improvements Program for Fiscal Year 2001-02 through Fiscal Year 2003-04:

Program	**Total Cost**
Community and Economic Development	$27,000,000
Development Services	$700,000
Engineering and Capital Projects	$7,000,000
Environmental Services	$26,000,000
General Services	$7,000,000
Library	$60,000,000
Park and Recreation	$95,000,000
Public Safety	$54,000,000
Real Estate Assets-Airport	$2,000,000
Qualcomm Stadium	$6,000,000
Sewer and Water	$708,000,000
Special Projects	$440,300,000
Transportation	$284,000,000
Total	**$1,717,000,000**

V. City and County of San Francisco

POPULATION	801,377
AREA	46.7 square miles
WEBSITE ADDRESS	http://www.sfdpw.com

FORM OF GOVERNMENT

The City and County of San Francisco are a consolidated city and county with boundaries that are prescribed by the laws of the State of California and the City Charter. The first City Charter was established on April 15, 1850. The current City Charter was adopted November 6, 2001. The local government consists of a legislative branch consisting of an 11-member Board of Supervisors, and an executive branch consisting of a Mayor. Each member of the Board is elected by district and serves a four-year term, but may not serve for more than two successive terms. The Mayor is the chief executive officer and official representative of the City and County who is elected at a general election and serves a four-year term, but may not serve for more than two successive terms. Voters elect the City Attorney every four years. The Controller and City Administrator are appointed by the Mayor every ten and five years, respectively. Commissions and department heads are generally appointed by the Mayor and confirmed by the Board of Supervisors. With few exceptions, all other officials and employees of San Francisco are subject to the civil service provisions of the Charter.

DEPARTMENT OF PUBLIC WORKS

The Deputy Director for Engineering, who also holds the title of City Engineer, is in charge of four bureaus in the Department of Public Works: Bureau of Engineering, Bureau of Architecture, Bureau of Construction Management, and Bureau of Street Use and Mapping. The first three bureaus, referred to as the Tri-bureaus, work on capital projects while the Bureau of Street Use and Mapping regulates the use of city streets and private development of infrastructure.

The Tri-bureaus are responsible for the planning, design, and construction of public streets and infrastructure. These services are provided for client departments who do not have technical capabilities or contracting authority. These include the Police, Fire, Health and Recreation and Park departments as well as many other city agencies.

Tri-bureau personnel work on street renovation, sewer replacement and enlargement, traffic signals, parks and playgrounds, libraries, police and fire stations, health facility, treatment plant and pump stations, and other public works projects.

The Tri-bureau has 435 authorized positions of which over 360 are filled. These positions cover many different disciplines including engineering, architecture, surveying, drafting, environmental, and construction management.

PROJECT MANAGEMENT/DELIVERY

The Tri-bureaus use a strong project management delivery system in which the projects are assigned to a project manager who is responsible for the budget and schedule from planning through project closeout. Project funding is usually generated from special funds including general obligation and revenue bonds, sales tax revenues, and grants. The Tri-bureaus have a philosophical approach to design-bid-construct project delivery with the objective of using in-house resources whenever possible to provide design and construction management. Consultants are used to supplement in-house resources when necessary.

CONSTRUCTION CONTRACTS/CAPITAL IMPROVEMENT PROGRAM

This information was not available.

VI. City of San Jose

POPULATION	918,000
AREA	177 square miles
WEBSITE ADDRESS	http://www.ci.san-jose.ca.us/

FORM OF GOVERNMENT

San Jose has a Mayor-Council-City Manager form of government as provided by City Charter. The current City Charter became effective in May 1965. The Mayor is elected by the people every four years. The people elect ten City Council members representing ten districts for four-year overlapping terms. The City Charter limits the Mayor and Council members from serving more than two consecutive terms. The City Attorney, Redevelopment Director, City Auditor, City Clerk and Independent Police Auditor are appointed by Mayor and Council. Department directors appointed by the City Manager, but require Council confirmation. Department directors, assistant and deputy directors serve at-will. Other employees of the City are subject to the civil service provisions of the Charter.

DEPARTMENT OF PUBLIC WORKS

MISSION: Plan, Design and Construct Public Facilities and Infrastructure Systems to Enhance the Quality of Life for the Residents of San José.

The Public Works Department has the primary responsibility to deliver facilities and infrastructure that meet the needs of the residents of San José and that comply with the standards and requirements established in the engineering guidelines and the City's Master Plans. The Department achieves its goals through planning, design and construction of the City's capital projects, and also through the plan review and permit process to regulate and facilitate private development projects. The Director of Public Works/City Engineer manages the Department.

Department personnel work on the expansion and modernization of over 2,434 miles of streets, 926 miles of storm drains, 2,169 miles of sewer lines, 3,500 acres of parks and the design and construction of recreation facilities, police and fire stations, libraries, municipal buildings, bridges, and other public works projects. Recently completed projects include the renovation of the Central Service Yard, the Trimble Road Bridge, and reconstruction of the Norman Y. Mineta SJIA Runway 30L.

The Department employs over 400 employees in many different disciplines including engineering, architecture, landscape architecture, surveying, drafting, real estate, and construction management. Major projects currently underway include a new Civic Center, Federal Inspection Facility at Norman Y. Mineta SJIA, and construction of the new West Valley Branch Library. Major programs include the $228 million Parks Bond, $211 million Branch Library Facilities Bond and the $159 million Fire and Police Stations and Facilities Bond.

PROJECT MANAGEMENT/DELIVERY

The Department has a focus of "on time, on budget" and reports performance measures in the categories of timeliness, cost, quality, and customer satisfaction in the annual Operating Budget. Project management is a team effort in which the projects are assigned to a client partner and a DPW project manager. The client provides scope and funding and the project manager is responsible for the budget and schedule. The project manager is involved with design and problem resolution but passes construction management responsibilities to a construction manager from the same division.

Project funding is the responsibility of the client department and be generated from special taxes, bonds, in-lieu fees, and grants. The seven divisions (not including Administration) within the Department use a design-bid-build system for project delivery. Design has shifted from mostly in-house to over 70% consultant design, often using master agreements for multiple projects. This has taken place in order to meet a large increase in workload from approximately $600 million in bond funds, the new Civic Center, plus an aggressive airport expansion program. Construction management remains largely in-house, augmented with consultants for special assignments.

CONSTRUCTION CONTRACTS/CAPITAL IMPROVEMENT PROGRAM

Major construction contracts to be awarded Fiscal Year 2001-02 through Fiscal Year 2003-04 (design and cm included, rounded to $1,000,000):

Program	Total Projects	Total Cost
Public Safety Bond	12	$37,000,000
Library Bond	20	$99,000,000
Parks/Recreation Facilities	160	$158,000,000
Airport Master Plan	10	$120,000,000
Civic Center	1	$246,000,000
Wastewater Program	21	$96,000,000
Storm Drainage	6	$5,000,000
Traffic	100	$194,000,000
Total	**302**	**$955,000,000**

C. SIMILARITIES AND DIFFERENCES

This section of the report summarizes similarities and differences among the participating agencies. This information may be useful as background when comparing the process benchmarking results and performance curves that are found in subsequent sections of this report.

The discussion is based on three pieces of information provided by the agencies:

- Agencies summaries (the preceding section)
- Available In-House Project Delivery Services (Table D)
- The Fact Sheet (Table E)

I. Agencies Summaries

All agencies have a similar form of government. Mayors and Council members are elected by the people to four-year terms. Mayors, with City Councils' approval, appoint other personnel. The number of Council members varies by city based on the number of districts.

All agencies rely on in-house resources for delivering Capital Improvement Projects and have primary disciplines in-house (civil engineering, architecture, construction management, surveying, and drafting). Consultants are only used to supplement in-house resources.

All agencies implement a strong management approach. Project managers are responsible for budget, schedule, and quality management from beginning of design to completion of closeout. In the City of San Jose, the project manager is also assisted by the client/partner, and during construction the management task is delegated to a construction manager in the same division.

The agencies have diverse numbers, sizes, and types of projects planned for the next two- years. All agencies have allocated large amounts of capital for transportation/airport and water/sewer/wastewater projects. The City of Long Beach has also allocated a considerable budget for public facilities.

II. Available In-House Project Delivery Services

Table D summarizes the agencies' project delivery services that are available in-house. All agencies conduct project delivery activities in-house before design starts. Also, during the design phase all agencies conduct civil works design in-house and the majority of agencies have in-house capacity to work on other disciplines (architectural, structural, mechanical, etc.). All agencies are capable of conducting in-house construction management, surveying, real estate, and scheduling tasks. Los Angeles is the only city that provides in-house geotechnical services.

III. Fact Sheets

Table E show that all agencies, with the exception of City of Los Angeles, have similar levels of consultant usage in delivering their Capital Improvement Projects. The number of full-time employees varies due to agencies' demographic factors (population and area). The City of San Diego has planned the largest amount of Capital Improvement Projects for the next three years. Taking the population of the cities into account, all agencies are planning to spend at similar levels on the Capital Improvement projects, per capita, with the City of San Diego being the highest.

Table D – Available In-House Project Delivery Services
(For Projects > $100,000 Construction Cost)

Project Delivery Services / Agency	City of Long Beach DPW	City of Los Angeles DPW / BOE	City of Sacramento DPW	City of San Diego Engineering & Capital Projects	City & County of San Francisco DPW/BOE/ BOA/BCM	City of San Jose DPW
Planning	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE
Pre-Design	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE
Design						
Architectural		AVAILABLE	AVAILABLE		AVAILABLE	AVAILABLE
Structural		AVAILABLE			AVAILABLE	AVAILABLE
Mechanical		AVAILABLE	AVAILABLE		AVAILABLE	AVAILABLE
Electrical		AVAILABLE	AVAILABLE		AVAILABLE	AVAILABLE
Civil	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE
Instrumentation & Control		AVAILABLE			AVAILABLE	AVAILABLE
Materials Pre-qualification		AVAILABLE		AVAILABLE	AVAILABLE	AVAILABLE
Geotechnical		AVAILABLE				
Construction Management	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE
Survey	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE
Real Estate	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE
Estimating	AVAILABLE	AVAILABLE	AVAILABLE		AVAILABLE	AVAILABLE
Environmental	AVAILABLE	AVAILABLE		AVAILABLE	AVAILABLE	
Scheduling	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE
Construction Inspection	AVAILABLE		AVAILABLE	AVAILABLE	AVAILABLE	AVAILABLE
Contract Compliance (Material Testing, Laboratory Services)				AVAILABLE	AVAILABLE	AVAILABLE

Modified Table E – Fact Sheet
CIP Spending Per Capita (3 Years)

City	3 Year Planned CIP (Million Dollars)	Population	3 Year CIP Per Capita (Dollars / Person)
Los Angeles	1,444	3,694,820	391
Long Beach	264	441,859	597
San Francisco	617	801,377	770
Sacramento	380	418,700	908
San Jose	955	918,000	1040
San Diego	1,717	1,277,168	1344

Table E – Fact Sheet

Agency	Total CIP Value Planned for FY 2001-02 Through FY 2003-04 *(Million Dollars)*	Number of Full-Time Employees *(Authorized Positions)*	Consultant Usage *(Percentage of CIP in Dollars)*
Long Beach, Department of Public Works	264	90	70%
Los Angeles, Department of Public Works/ Bureau of Engineering	1,444	1,128	30%
Sacramento, Department of Public Works	380	100	70%
San Diego, Engineering & Capital Projects	1,717	415	70%
San Francisco, Department of Public Works / Bureau of Engineering / Bureau of Construction Management / Bureau of Architecture	617	435	70%
San Jose, Department of Public Works	1,190	470	70%

Chapter 4

Study Methodology

CHAPTER 4 Study Methodology

A. APPROACH

The City of Los Angeles developed a step-by-step approach to the *CIP Benchmarking Study* (see briefing document in Appendix A) that would guide how to:

- Categorize projects and their costs
- Define phases of projects and their durations
- Select projects for inclusion in the study
- Accomplish both process and performance benchmarking objectives in the study

The step-by-step approach is summarized below.

I. Categorizing Projects

The project team identified project types and classifications during their first meeting. Table F lists the three project types and 11 classifications used in this study. (Treatment facilities were not included because many of the agencies were not responsible for water or wastewater treatment.)

In this study, "regression curves" are graphs that show the trend of various costs of project delivery compared to overall construction costs. The purpose of developing these curves is to provide a tool that allows agencies to budget reasonably and appropriately for future project delivery costs.

The study team requested each participating agency to provide eight to ten projects from each project category. Regression curves were ultimately developed at the project classification level as well as the project type level. A statistical analysis was performed to investigate alternative groupings in order to develop performance

Table F – Categorizing Projects

Project Types	Project Classifications
Municipal Facilities	Libraries
	Police / Fire Stations
	Community Buildings / Recreational Centers / Child Care / Gymnasiums
Streets	Widening / New / Grade Separation
	Bridges (Retrofit / Seismic)
	Renovation/Resurfacing
	Bike/Pedestrian/Curb Ramps
	Signals
Pipe Systems	Gravity Systems (Storm Drains, Sewers)
	Pressure Systems
	Pump Stations

benchmarking models. The analysis confirmed statistical validity of the **regression curves** at the project classification level, using the existing pool of data. All regression curves are provided in Appendix D and are used for the analysis (Chapter 6). Readers can refer to Section 7 C (pages 64-66) and Appendix B-I (page B-3) of this report for further discussion on this topic.

II. Defining Project Phases

The study group proposed data collection from five project phases (Pre-Design, Design, Bid & Award, Construction, and Post-Construction). Some participating agencies could not segregate their costs into these categories. They do not break down project delivery costs into these smaller, succinct categories and do not handle all of the project delivery functions within the public works or engineering department (e.g., project planning activities may be handled by an agency's planning department before the project is handed over to the public works department for completion).

All agencies were able to break down costs for design and construction phases. Therefore these became the two project phase categories defined for this study. The design phase is distinguished from the construction phase by the notice-to-proceed date.

III. Defining Project Duration

The participating agencies agreed that the duration of the **design phase** of a project would begin with the initial concept - which requires a complete scope of work - and end with the issuance of a construction notice-to-proceed.

The duration of the **construction phase** would begin with the construction notice-to-proceed and end with project closeout.

Projects that experienced extensive suspension of progress would subtract that downtime from the overall elapsed time to show a more realistic project duration.

IV. Classifying Costs

The performance benchmarking study used the following five cost categories:

1) **Design Costs**: The design phase (and associated costs) begins with the initial concept, includes planning as well as design, and ends with the issuance of a construction notice-to-proceed. Design costs consist of direct labor costs, other direct agency costs such as art fees and all necessary permits, and consultant services cost associated with planning and design. Design may include the following:

- Pre-Design
    - Complete schematic design documents
    - Program scope review and development
    - Program evaluation of schedule and budget
    - Review of alternative approaches to design and construction
    - Obtain owner approval to proceed
    - Attend hearings and proceedings in connection with the project.
    - Prepare feasibility studies
    - Prepare comparative studies of sites, buildings, or locations
    - Provide submissions for governmental approvals
    - Provide services related to future facilities, systems, or equipment
    - Provide services as related to the investigation of existing conditions of site or buildings or to prepare as-built drawings
    - Develop life cycle costs
    - Complete environmental documentation and clearances
    - Manage right-of-way procurement process

- Design
    - Complete design development documents including outline specifications
    - Evaluate budget and schedule against updated estimate
    - Complete design and specifications
    - Develop bid documents and forms including contracts
    - Complete permit applications
    - Coordinate agency reviews of documents
    - Evaluate budget and schedule against updated estimate
    - Review substitutions of materials and equipment
    - Prepare additive or deductive alternate documentation
    - Coordinate geotechnical, hazardous material, food services, acoustic or other specialty design requirements
    - Provide interior design services
- Bid and Award Tasks
    - Prepare advertisement for bids
    - Perform prequalification of bidders
    - Manage the pre-bid conference
    - Perform the bid evaluations
    - Prepare the recommendation for award
    - Obtain approval of contract award from Board/Council
    - Prepare the notice to proceed

2) **Construction Management Costs:** All the costs associated with the management of the construction of the project, including closeout costs, are included in this category. Construction management costs consist of direct labor, other agency costs, and consultant usage. Construction management may include the following:

- Construction Phase
    - Pre-construction conference
    - Review and approve schedule and schedule updates
    - On-site management
    - Review of shop drawings, samples, and submittals
    - Testing and inspection
    - Payment request processing
    - Change order review, estimating, and negotiations
    - Monthly reports to owner and agencies
    - Project accounting and cost management
    - Responding to requests for information
    - Developing and implementing a project communications plan
    - Document control
    - Claim management
    - Final inspections and punch list development and tracking
- Closeout Phase
    - Commissioning of facilities and equipment
    - Training of maintenance and operation personnel
    - Warranty and guarantee tracking and documentation
    - Move-in planning
    - Filing of notices (occupancy, completion, etc.)
    - Checking and filing as-built documents

3) **Total Delivery Costs:** This is the total cost of delivering a capital improvement project. It is also the total of the design cost and construction management cost indicated above.

4) **Change Order Cost:** This consists of all change orders, including:

- Unforeseen and changed conditions
- Design changes
- Owner-initiated changes
- Commissioning/optimization
- Miscellaneous

The team collected data on credit change orders but did not include extensive analysis of the data in this study.

5) **Construction Cost:** This is the direct construction cost, including all change orders during the construction phase (from the issuance of notice-to-proceed to substantial completion/beneficial occupancy). The following costs are associated with construction and are included in the total construction cost:

- Direct actual construction
- Total amount of positive change orders throughout construction
- Fixtures, furnishing, and equipment (FFE)
- Utilities relocation
- Work performed by the agency's staff and other agencies' staff

The participating agencies decided to use fully burdened costs for project delivery tasks because agencies' multipliers were similar. They also agreed that land acquisition costs should be excluded from the total construction cost.

"Outliers in a regression analysis" are simply those projects that are highly atypical, and when included in the analysis of data, have the potential to skew the results – such as the project mentioned above that includes wetlands mitigation (highly uncommon among public works projects). Careful judgment is required when determining which projects fall into the "outlier" category because most public works projects have unique factors that influence costs.

V. Selecting Projects

All agencies provided information on projects that were constructed during the last five years. None of these were completed before July 1, 1996.

All of the selected projects had to be "representative of the agencies' processes". This approach ensured that projects that had the potential to be **outliers in the regression analysis** (that would dramatically and incorrectly skew the results) would be eliminated from the benchmarking effort. For example, if wetlands mitigation (purchase or creation) was part of a project (which would be highly atypical of the agency's projects), that project should not be included in the study.

A statistical elimination process was developed in addition to intuitive elimination of the non-representative projects to help ensure the validity of the data used in this benchmarking study. This technique was not particularly effective at validating the data because of the relatively low number of projects included in Phase 1. The process is mentioned here and described fully in Appendix B-II (see page B-15) because it may be very useful in future phases of the study when a larger, more statistically reliable number of projects has been analyzed.

VI. Performance Benchmarking Versus Process Benchmarking

This study approached benchmarking in two ways: through process and performance.

1) **Process Benchmarking:** The study team developed a questionnaire that sought information about the processes that each agency followed to deliver its projects. The outcome of the process

benchmarking study was the identification of 15 common best management practices and 24 recommended best management practices.

2) **Performance Benchmarking:** The study team developed another questionnaire that sought information about project costs. Data from the six agencies were plotted on regression curves that compare project delivery costs to overall construction costs.

Process benchmarking was intended to compare each agency's practices to their project delivery performance in order to determine the best practices in the industry. Because some of the agencies have significantly modified their project delivery practices over the study period – the last five years – the study team decided to approach process benchmarking by developing a consensus on an inventory of practices that they believed would represent the best practices in the industry.

The study group used this approach to develop and refine a process questionnaire for participating agencies. The agencies responded to each question using a scale of 1 to 5. A rating of 5 indicated that the agency implemented the process strongly. A rating of 0 indicated that the agency was not implementing the process. A composite score would indicate an agency's commitment to implementing the proposed processes.

Common best management practices (currently used by the majority of the agencies and ranked highly in the process questionnaire) and recommended best management practices (whose full implementation was believed to be beneficial to all agencies) were identified based on this process benchmarking, and following team discussions. (Refer to Chapter 5.)

B. BASIS FOR DATA COMPARISON AND PARAMETERS

Construction costs can be benchmarked two ways: **against costs of project delivery items** (design, construction management, or total delivery) or **against hours of effort spent on the project delivery tasks**. While the "hours" basis provides a more realistic picture of agencies' performance, the "costs" basis was rationalized as follows:

- For some agencies it was practically impossible to extract project specific hours information from their accounting systems and/or segregate these hours by project phases
- Agencies' multipliers are in the same range, as reflected in Appendix A-II (page A-7) and discussed below. Therefore, the benchmarking study team concluded that comparing agencies' costs would accurately represent the efforts or hours to deliver projects.

Administrative costs for all participating agencies are summarized in Appendix A-II (page A-7).

Pages A-9 through A-14 of Appendix A-II summarize the agencies' administrative costs breakdown. The study team identified the following categories of administrative costs as the most appropriate and comprehensive categories for comparing data:

1) Fringe Benefits: Includes all benefits provided to the agency employees, such as insurance, retirement plan, workers compensation, etc.
2) Compensated Time Off: Employees' personal time that is compensated through vacation, sick days, holidays, etc.

3) City Overhead: Accounts for the time that the city personnel spend on agency related tasks such as accounting, budgeting, auditing, etc.
4) Department Overhead: Indirect costs within each department associated with projects administration. Examples are accounting, claims management, and director's office.
5) Agency Overhead: Related to the agency's general administrative costs such as salaries of the city engineer, deputies, and division heads, and office expenses such as rent, phone, equipment (similar to department overhead)

In general, all participating agencies have the same administrative items, although categorized differently. This is an important commonality among the agencies that resulted in the "discovery" of similar multipliers and provided the rational for considering "costs" based benchmarking equivalent to "hours" based benchmarking.

Appendix A-III (page A-15) demonstrates how each agency's multipliers can be used to translate delivery costs into the in-house delivery effort necessary for each million dollars of construction cost. This sample calculation is included to provide an approximate estimate of the equivalent in-house human resources required to design a construction project with known construction value. A similar calculation can be used to estimate construction management effort. Total project delivery effort can be estimated as the sum of design effort and construction management effort.

Chapter 5

Process Benchmarking






CHAPTER 5 Process Benchmarking

A. GUIDING PRINCIPLES

Executive level technical staff from six major cities (the project team) shared and openly discussed the effectiveness of their capital project delivery methods. This project team identified, discussed, and evaluated 98 processes associated with the effective delivery of capital projects.

Process benchmarking was "agency specific" (as opposed to "project specific"). The process benchmarking procedure consisted of:

- Identifying key processes used to deliver capital improvement projects
- Determining the extent to which these processes were used by each agency
- Identifying those processes that were "common best management practices" (used by most agencies) and "recommended best management practices" (processes that most participating agencies believed should be implemented to deliver high quality projects faster and at lower cost)
- The participating agencies, which have over 300 person-years of experience among them, used this experience to intuitively (rather than statistically) identify the best management practices that led to projects that were delivered quickly and at low cost

Process benchmarking focused on the business procedures related to the delivery of projects. The project team grouped the key processes into six categories:

I. Planning
II. Design
III. Quality Assurance / Quality Control
IV. Construction Management
V. Project Management
VI. Consultant Selection and Use

The study team developed a detailed, six-page questionnaire that asked for information about each of the key process categories (Appendix C, page C-1). All processes in this questionnaire were reviewed in a group discussion and the questionnaire was modified to reflect the project team's comments.

B. DATA COLLECTION

The process questionnaire asked each agency to rate the degree to which they had implemented each process - with "0" indicating the process had not been implemented in any projects and "5" indicating full implementation in all projects at the time of the survey. The study team collected responses from each agency for each process and calculated the average among all agencies. The study team determined that a high average (2.8 or greater) score in combination with low diversity of scores among agencies should indicate that a process was in common use among the six agencies and therefore could be considered a "common best management practice." This criterion, however, would not restrict the team from intuitively eliminating high-score processes and/or including low-score processes if appropriate. Table G is a list of fifteen "common best management practices." Details of the agencies' responses are contained in Appendix C .

The participating agencies then met to identify "recommended best management practices." They used collective experience, as well as process benchmarking outcomes, to identify processes that they believed would improve delivery of capital projects. The agencies took a consensus approach, based on process benchmarking, to determine which processes should be recommended best man-

Table G – Common Best Management Practices

Process Category	Ref.*	Common Best Management Practices
Planning	1.a.	Capital projects are well defined with respect to scope and budget at the end of the planning phase
	1.f.	There is a master schedule attached to the CIP that identifies start and finish dates for projects
	1.i.	Projects are shown on a geographical information system
Design	2.d.	Designers are required to provide a work plan or design schedule prior to design start
	2.g.	Designs are done on 2D CAD systems
Quality Assurance / Quality Control	3.I.d.	Agency uses standard forms for RFIs, change orders, pay applications, field clarifications, minutes of meetings, etc.
	3.III.g.	Inspectors are trained and, when required, certified
Construction Management	4.I.f.	A change order contingency is set aside at the start of the project.
	4.I.d.	A formal change order process is in place that defines all forms and methods necessary to finalize change orders
Project Management	5.1.d.	A project manager is assigned to every project
	5.1.e.	Project manager has "cradle to grave" involvement
	5.III.a.	A standard project control system has been adopted by the Agency and is in use on all projects
Consultant Selection and Use	6.h.	The consultant selection process is qualification based
	6.c.	A standard consultant contract is included in the RFQ/RFP
	6.f.	An annual RFQ/RFP solicitation is used to develop an on-call list of pre-approved consultants

* Reference to the process question in Appendix C (pp. C-1 – C-6)

Table H – Recommended Best Management Practices

Process Category	Ref.*	Recommended Best Management Practices
Planning	1.b.	Complete project feasibility studies prior to defining budget and scope
	1.d.	Establish a Board/Council project-prioritization system
	1.e.	Provide resource loading for projects listed in the CIP for design and construction
Design	2.f.	Define requirements for reliability, maintenance, and operation prior to design start
	2.b.	Provide a clear, precise scope to designers prior to design start
	2.i.	Adapt successful designs to project sites, whenever possible (e.g. fire stations, gymnasiums, etc.)
	N/A	Develop and use Green Buildings Standards
Quality Assurance / Quality Control	3.III.a.	Use a formal quality management system
	3.I.a.	Develop and use a standardized project delivery manual
	3.II.b.	Perform a formal value engineering study for projects larger than $1,000,000
	3.III.b.	Perform and use post project reviews for lessons learned
Construction Management	4.IV.a.	Involve the construction management team before completion of design
	4.I.g.	Set aside 15% for construction change order contingency
	4.I.a.	Delegate authority to the City Engineer / Public Works Director to approve change orders to the contingency amount
	4.I.m.	Classify types of changes
	4.II.a.	Include a formal dispute resolution procedure in all contract agreements
	4.III.a.	Use a team-building process for projects greater than $5 million.
	N/A	Delegate authority for change order approval to the departments, in order to reduce paperwork
	N/A	Establish construction award limits for to support awards by the director without a Board approval
	N/A	Establish a contractor pre-qualification process for large, complex projects
Project Management	5.I.f.	Assign a client representative to every project
	5.II.a	Provide formal training for project managers on a regular basis
Consultant Selection and Use	6.e.	Delegate authority to the PW Director/City Engineer to approve consultant contracts under $250,000, when a formal RFP selection process is used
	6.g.	Implement and use a consultant rating system that identifies quality of consultant performance

* Reference to the process question in Appendix C (pp. C-1 – C-6). N/A indicates that the recommended best practice was the outcome of the team discussion and was not a process question.

agement practices. Table H lists the 24 best management practices that the project team recommended for efficient project delivery.

C. EXPLANATION OF RECOMMENDED BEST MANAGEMENT PRACTICES

This section provides a summary description of the 24 recommended best management practices listed in Table H:

Planning

- *Complete **project feasibility studies** prior to defining budget and scope:* Feasibility studies should be completed early in the process so that issues are identified and either resolved or accommodated within the final scope, budget, and project delivery schedule. This will also reduce overall project delivery costs.
- *Establish a Board/Council **project-prioritization system**:* Departments have limited resources to commit to projects and these resources may be impacted by market conditions or delayed project deliveries. A Board/Council priority system and designation for each project will ensure that resources are directed to the community's highest priorities.
- *Provide **resource loading** for projects listed in the CIP for design and construction:* The resources required to deliver a project according to the schedule mandated by the Board/Council should be committed at the time the project becomes part of the CIP. This will ensure that existing resources are not over-committed.

Design

- *Define **design requirements** for reliability, maintenance, and operation prior to design start:* The design process will determine the reasonableness of future maintenance and operation costs of facilities. Reliability, maintenance, and operational requirements should be clearly defined in advance and should be included in the design professional's contract when a consultant is used.
- *Provide a **clear, precise scope** to designers prior to design start:* Design professionals will work more efficiently if given a clear scope when contracted to provide the design services. Clear scope and budget should be defined in advance and made a part of the design professional's contract if/when a consultant is used.
- ***Adapt successful designs** to construction sites whenever possible (e.g. fire stations, gymnasiums, etc.):* Successful designs of fire stations, police facilities, maintenance facilities, pump stations, and many other projects should be re-used when possible. Site adaptations of successful designs may reduce design costs by half.
- *Develop and use **Green Buildings Standards**:* Communities have a stake in the environment as well as in the cost of operating and maintaining public facilities. Utilizing "Green Building Standards" allows facilities to be built and operated with renewable resources and other environmentally sound practices.
- *Develop and use a standardized **project delivery manual**:* Standardized procedures streamline project design, bidding, and construction processes. Standardized design management procedures will reduce scope

creep and delays in construction document preparation. During construction, standard procedures will reduce response times on RFI's, and add overall clarity and efficiency to the construction administration process. The manual will also reduce the time necessary for project documentation training.

Quality Assurance/Quality Control

- *Use a formal **quality management system:*** Quality management should include all activities from the preparation of design documents through the closeout of construction. The implementation and tracking of quality control should be formalized to ensure application on important community projects.
- *Perform a formal **value engineering study** for projects larger than $1,000,000:* While the "first cost" of a facility and/or equipment is important, the "total life cycle" cost must be the primary concern of the responsible public agency charged with project delivery. Value engineering studies will ensure that all costs are considered in the selection of major facility components and equipment.
- *Perform and use **post project reviews** for lessons learned:* Post project reviews should consist of lessons learned on prior projects of a similar scope and nature. This is expected to make future project management and delivery more efficient and cost effective.

Construction Management

- ***Involve the construction management team*** *before completion of design:* Experienced contractors and construction managers should be included in the design process to make designs more constructible and lower cost. Construction managers and contractors are frequently more experienced about the products and/or equipment that are readily available. They can also contribute to selections and decisions during the design process that will facilitate construction procurement, means and methods.
- *Set aside 15% for construction **change order contingency:*** A 15% change order contingency would allow most projects to be completed, inclusive of all changes, with no additional funding actions required by the Council or Board.
- ***Delegate authority to the City Engineer / Public Works Director*** *to approve change orders up to the contingency amount:* Change order work should be authorized as soon as is practically possible in order to avoid potential delays to critical work. Scheduling a significant change order for review and authorization by the Board may delay project progress, even though it may be within the contingency amount allowed in the project budget. Authorization of the City Engineer/ Public Works Director to approve changes within the contingency budgeted for changes will ensure that critical changes are acted on promptly and that delays are minimized.
- ***Classify types of changes:*** Classification of change orders into categories such as changed conditions, unforeseen conditions, owner requests, or design changes for owner use improves project delivery processes
- *Include a formal **dispute resolution procedure** in all contract agreements:* Construction is acknowledged as a dispute prone industry. As such, it makes sense to provide options in the contract documents to avoid litigation over disputes.
- *Use a **team-building process** for projects greater than $5 million:* Partnering is a team-building process that has a proven record of improving working relationships and production, and reducing claims and disputes on construction projects. It is one of several

team-building processes that should be used in the interest of reducing conflict and facilitating project delivery.

- *Delegate **authority for change order approval** to the departments to reduce paperwork:* Change order decisions should be made at the lowest management level possible, in order to avoid delays to critical activities during construction.
- *Establish **construction award limits** to support awards by the director without Board approval:* Authorizing the Director or City Engineer to award construction projects will expedite the start of projects and thereby reduce administrative costs
- *Establish a **process to pre-qualify** contractors for large, complex projects:* Prequalification helps screen contractors for prior performance on similar projects, safety and financial capability

Project Management

- *Assign a **client representative** to every project:* Client (user) representation during the life of the project will expedite decisions on submittals, substitutions, and changes. Their involvement will also help determine intent and streamline the commissioning and occupancy process.
- *Provide **formal training** for project managers on a regular basis:* Project Managers come to projects with varying degrees of skill and familiarity with agency procedures. Orientation and training will improve their ability to deliver the project on the intended schedule.

Consultant Selection and Use

- *Delegate authority to the PW Director/City Engineer **to approve consultant contracts under $250,000**, using a formal RFP selection process:* Authorization for the Public Works Director/City Engineer to award consulting contracts ensures earlier start of design and construction management activities and will reduce consultant selection process costs.
- *Implement and use a **consultant rating system** that identifies quality of consultant performance:* The performance of consultants should be tracked so that those who deliver quality services at reasonable costs can be adequately considered for future awards.

Chapter 6

Performance - Benchmarking

CHAPTER 6 Performance Benchmarking

A. GUIDING PRINCIPLES

Performance benchmarking consisted of collecting documented project costs and comparing project **delivery** costs with **total construction** costs.

The participating agencies and the study team developed a performance questionnaire to collect performance data. Appendix D-I (page D-3) includes a sample performance questionnaire. Highlights of the questionnaire are as follows:

- Project costs include two delivery phases: Design and Construction "Design Costs" include both planning and design. The project team would like to have segregated the costs of design from planning functions, but this was not possible given the current data. "Construction Costs" include all construction management and direct costs of construction.
- A "Complexity Index" was used to account for possible influence of projects' complexity on their performance. For "Simple" and "Complex" projects, agencies were requested to provide justification for their indicated complexity index.
- Similarly, new construction or rehabilitation/renovation could impact performance. Therefore, the questionnaire included an index of "New" versus "Rehabilitation" construction.
- The total cost of each phase might include some costs other than labor, such as "art fees". These are reflected in the performance curves. (A description of how costs are broken down for the phases is provided in Chapter 4 pages 30-32, item III – Classifying Costs).
- After reviewing and comparing the Work Phases Breakdown Structure among the agencies, the study team concluded that agencies categorize most cost items similarly. Some exceptions are "Utility Relocation Costs", "City Forces Construction", and "Land Acquisition". Therefore, these items were not broken down among phases and "Land Acquisition" was totally excluded from the construction cost.
- The project team agreed to use "Total Construction Cost" (including all Change Orders) as the basis of benchmarking (X-axis of the graphs). "City Forces Construction" and "Utility Relocation Costs" were also included in the total construction cost.
- Agencies found that segregating client-driven change orders was impractical due to the lack of information. Therefore, they decided to not categorize change orders at this stage of the study. It will be considered within future phases of study.
- Costs of project delivery tasks (planning, design, and construction management) consist of direct labor, other direct costs (such as art fees), and consultants costs, {as reflected in the performance questionnaire (Appendix D-I, page D-3)}. Defining costs as inclusive of these elements allows agencies to include the cost of consultants in the benchmarking against total construction cost.

B. DATA COLLECTION

Participating agencies provided project information by responding to the performance questionnaire. The study team compiled the data into a database to develop performance curves.

C. DISTRIBUTION OF PROJECTS

Table K summarizes the final project distribution. It shows a large diversity in the number of projects. Table M shows the range of projects costs in various categories (project types and classifications). Additional data collection at future phases of this study will improve the study conclusions. Selected projects included a range of sizes so that the final data pool was representative of each agency's projects in each classification.

D. PERFORMANCE GRAPHS DEVELOPMENT

Project performance data are summarized and presented in Appendix D-II (page D-3). After compilation of the performance data into a Microsoft Access database, the study team developed a Visual Basic program to exchange performance data with Microsoft Excel in order to develop and review performance curves, using user-defined criteria.

This database will be used by the study participants to review and evaluate numerous benchmarking models and lessons learned from the data trends, in addition to what was reviewed and discussed in this current study. Following are some examples of the numerous models available in the database. These models will be more useful upon compilation of additional data and better distribution of projects at future phases of this study:

- Variations of change order costs with design cost, construction management cost, or total delivery cost
- Variations of project delivery costs with consultant usage
- Effects of consultant usage on total change order costs
- Construction management cost versus design cost
- Effects of project indices of various delivery costs

The database is designed to facilitate additional data collection and instant development of the performance graphs. It is also designed to simplify future modifications to the models criteria (e.g. using "Hours" basis, alternative categorizations and filtering, and effects of other agency cost such as art fees).

Various graphs with different options were developed. The project team decided to include the graphs listed in Table N in this study after a comprehensive review and based on participants' expectations. These graphs are provided in Appendix D-III (pages D-31 – D-74). The nine project type graphs for various project delivery costs (design, construction management, and total delivery) are also included in this section, as well as a summary of R^2 values (Table P), for better reference and comparison.

Table K – Projects Distribution Matrix

Project Type/ Classification \ Agency	Agency A	Agency B	Agency C	Agency D	Agency E	Agency F	TOTAL
Municipal Facilities							
Libraries	4	1	2	6	0	1	**14**
Police / Fire Station	2	1	6	7	0	3	**19**
Community Building / Recreation Center/ Children Center / Gymnasium	3	2	4	3	0	2	**14**
Streets							
Widening / New / Grade Separation	3	8	4	4	2	0	**21**
Bridges (Retrofit / Seismic)	7	0	4	6	0	2	**19**
Renovation / Resurfacing	5	9	7	0	7	0	**28**
Bike / Pedestrian / Curb Ramps	7	7	4	0	6	0	**24**
Signals	10	5	7	0	4	6	**32**
Pipe Systems							
Gravity System (Storm Drains, Sewers)	15	0	7	21	0	4	**47**
Pressure Systems	7	0	6	0	0	0	**13**
Pump Stations	2	0	6	0	0	0	**8**

Table M – Range of Projects Construction Costs

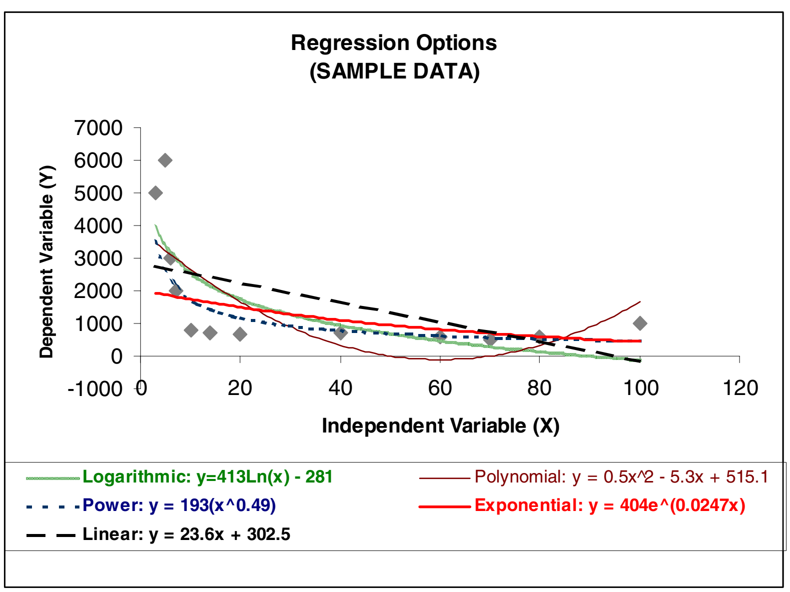
Project Type/ Project Classification	Approximate Range of Total Construction Cost (Including All Change Orders)
Municipal Facilities	**$207,000 - $28,041,000**
Libraries	$207,000 - $5,130,000
Police / Fire Station	$534,000 - $28,041,000
Community Building / Recreation Center/ Children Center / Gymnasium	$323,000 - $9,122,000
Streets	**$10,000 - $15,921,000**
Widening / New / Grade Separation	$237,000 - $15,921,000
Bridges (Retrofit / Seismic)	$53,000 - $11,475,000
Renovation / Resurfacing	$48,000 - $3,646,000
Bike / Pedestrian / Curb Ramps	$10,000 - $2,457,000
Signals	$64,000 - $1,176,000
Pipe Systems	**$34,000 - $13,176,000**
Gravity System (Storm Drains, Sewers)	$34,000 - $13,176,000
Pressure Systems	$264,000 - $1,880,000
Pump Stations	$1,710,000 - $8,290,000
Overall	**$10,000 - $28,041,000**

Table N – Performance Benchmarking Graphs

Curve Type	Title	Categorization	No. of Graphs
I & II	Phase Cost / Construction Cost Versus Construction Cost	2 Phases (Plan + Design, CM) 11 Classifications + 3 project types	28
III	Delivery Cost / Construction Cost Versus Construction Cost	1 Phase (Plan + Design + CM) 3 project types	3
IV	Change Order Cost / Construction Cost Versus Construction Cost	3 project types	3
V	Total Project Duration Versus Construction Cost	By Agency and Overall (All in one Graph) for 3 project types	3

The following agreements were reached regarding development of performance curves:

- Five regression options (shown in the following figure) were reviewed:
  - *Linear regression* assumes the dependent variable (e.g. design costs as a percentage of total construction cost) linearly changes with the independent variable (total construction cost)
  - *Logarithmic regression* assumes variations of the dependent variable becomes smaller as project size increases, in the form of a logarithmic function
  - *Polynomial regression* assumes that the dependent variable is a polynomial function of the independent variable
  - *Power regression* considers dependent variable a power function of the independent variable
  - *Exponential Regression* is the inverse of logarithmic regression and assumes that the dependent variable is an exponential function of the independent variable
- Logarithmic regression provided the most realistic trend and the best R^2 values in most cases. In reality, delivery costs for smaller projects are more sensitive to project size changes, due to some fixed costs that remain the same for small and large projects. This fact is best represented by a logarithmic function whose slope decreases as project size increases. In addition, a logarithmic regression can be translated to a linear regression that



simplifies statistical analyses. Therefore, the logarithmic regression option was used in this study.

- It was agreed that x-axis would represent the total construction cost, including all change orders. Caution must be taken when using these curves to predict delivery costs for a project whose total change order value is unknown.
- An upper-bound curve, parallel to the regression curve was identified as an important graphical element. A 70% confidence limit was determined to be the upper boundary. In other words, *assuming the proposed model can be used as a predictive tool, the delivery cost (Design, CM, etc.) of a new construction project has a 70% chance to fall below the upper-limit curve*. The process of selecting this upper-bound curve is summarized in Appendix B-III (page B-19), which shows that the actual confidence level is often more than 70% and may be as high as 85%.
- In each graph, one regression curve was developed for all data points. In this global regression, each agency's data is presented with a unique symbol to distinguish it from the others. It is noteworthy that an aggregation at this level limits the use of the curves to only "comparative tools" from a statistical viewpoint.
- Statistical outliers were not eliminated in this study. Nevertheless, the elimination process, as may be applied in future phases of the study, is explained in Appendix B-II (page B-15).
- An analysis on application of project indices was conducted and it was concluded that project indexing would not provide any valuable insight at this time. An analysis was performed to identify areas of additional data collection. This statistical analysis is summarized in Appendix B-IV (page B-25).

E. USES OF GRAPHED DATA

There are two purposes for these performance graphs. First, they can be used to compare past performance of each agency with the industry overall, as represented by the six participating agencies. Second, they can be used as a predictive tool to estimate various project delivery costs based on estimated construction cost, at bid time. However, caution is urged relating to the latter application until data on additional projects is available.

F. DISCUSSION

In order to learn how well the data points are modeled by a regression curve, "Goodness of Fit" can be evaluated using the R^2 parameter. R^2 is a value that evaluates proximity of data points to the regression curve. An R^2 equal to 1.0 represents a perfect fit and means that all data points fall exactly on the regression curve. An R^2 of 0.0 means that the regression model is totally inappropriate to represent data and may not be used to predict future trends. R^2's of all the generated curves are summarized in Table N, at the end of this chapter. The project team reviewed the R^2 values and trends of all graphs in each category of curves.

The following discussion is based on the performance graphs that follow (listed in Table N) and the R^2 values (Table P). This discussion is organized based on the curve groups (1 –5). For easier reference, the graphs for each category follow the corresponding discussion. Readers are encouraged to review the performance graphs in this chapter, and the other graphs in Appendix D-III (pages D-31 – D-74), before reading the following discussion.

Curve Group I

Design Cost / Construction Cost Versus Construction Cost:

Municipal Facilities:

Most of the Municipal Facilities projects follow a reasonable trend, showing a decrease in design%, as the project size increases. In the overall model (pages 48 and D-32) the R^2 value of 0.3586 indicates some room for improvement with additional data collection. It is crucial to emphasize the importance of the large projects. Projects larger than $8 million make a significant contribution to the logarithmic nature of the regression curve. Most of the projects fall around or below the regression curve.

Among the Municipal Facilities classifications, "Libraries" presents the most reasonable trend and the highest R^2 value (0.6544). "Fire / Police Station" classification has the lowest R^2 value (0.1384) and can be significantly improved with additional data collection, specifically on larger projects.

It can be concluded that Municipal Facilities projects have reasonable design costs (less than 50% of construction cost) and this percentage is smaller for larger projects. The regression curve has a desirable trend with some room for improvement with additional data collection.

Streets:

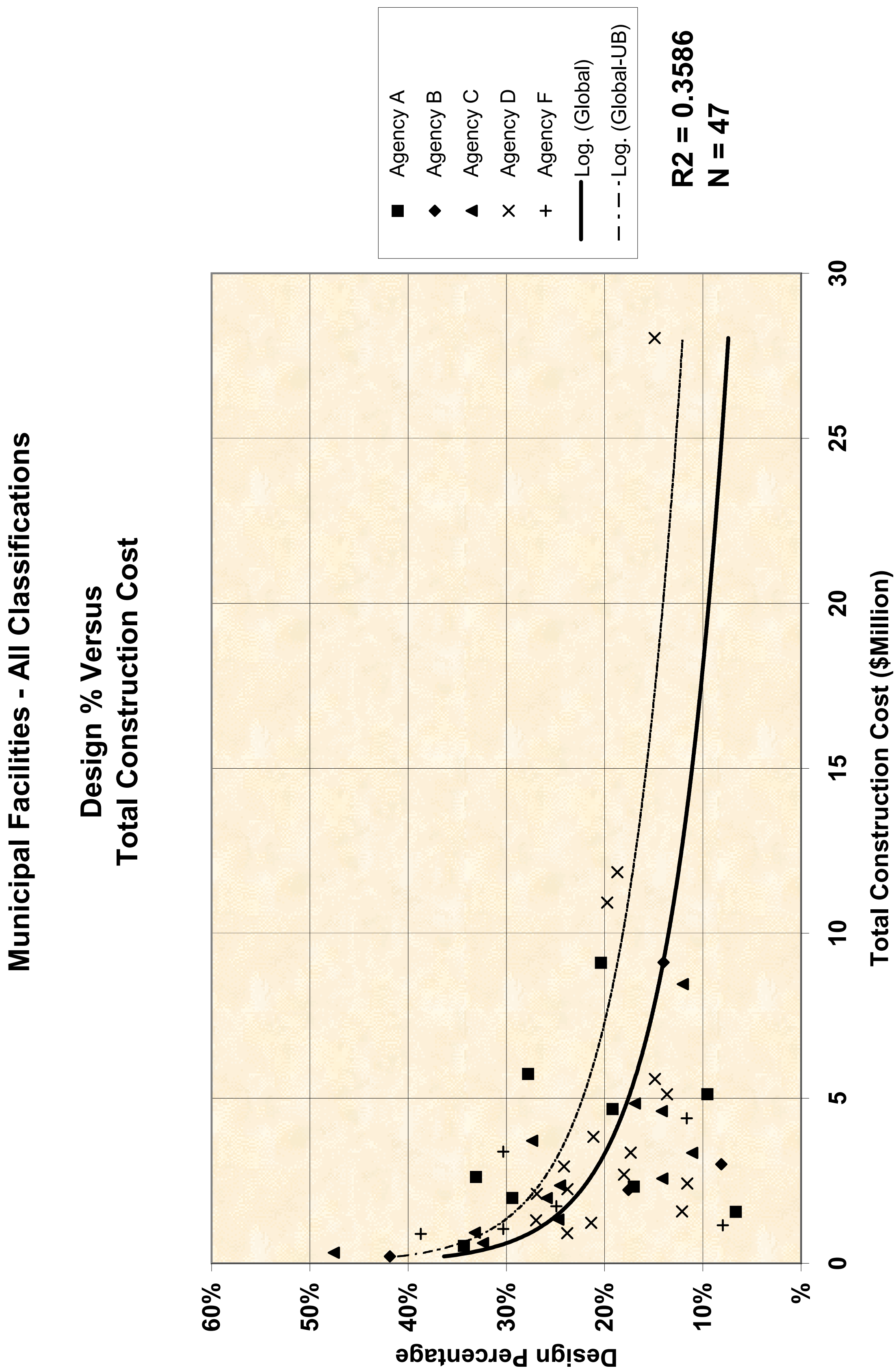
The global model for Streets projects has a realistic trend. However, the low R^2 value (0.1755) indicates much room for improvement. About 80% of the Streets projects are small projects with small design costs. Obviously, the small projects with extremely high design costs (more than 80% of total construction cost) make significant contribution to the current trend and low R^2 value of the model (refer to the complete curve in page D-36). Data collection on projects larger than $2 million and elimination of small projects with extreme design costs (outliers)[1] can significantly improve this category of curves.

The "Bike / Pedestrian / Curb Ramps" classification presents the best trend and the highest R^2 value in this category of curves. The relatively flat slope of "Renovation / Resurfacing" and "Signals" indicates that design cost, as a percentage of total construction cost, is not correlated with the project size (total construction cost). This finding may not be conclusive due to small R^2 values (0.0221 and 0.032 respectively). In conclusion, additional data collection is warranted, especially for the above two classifications and for large projects.

Pipe Systems:

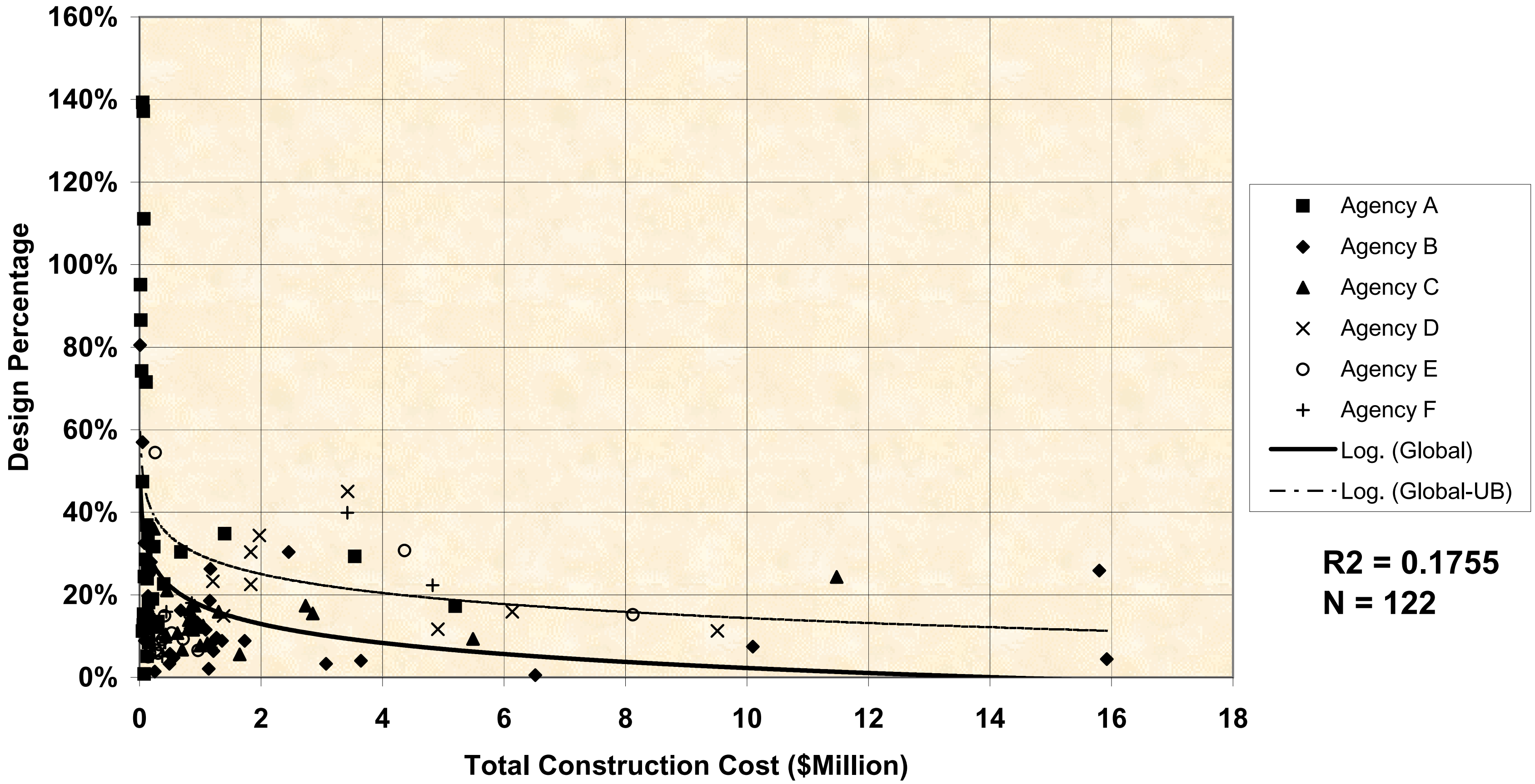
Four small projects with considerably high design% (more than 65%) are the main contributors to the area above the confidence limit. The few projects larger than $7 million make a significant contribution to the shape of the model. All classifications show a reasonable trend with "Gravity Systems" being the best. Additional data collection should emphasize on projects larger than $4 million, specifically in the "Pump Stations" and "Pressure Systems" classifications.

[1] Outliers are not eliminated in this study due to data scarcity. Refer to page 32 and Appendix B-II.


Municipal Facilities - All Classifications
Design % Versus
Total Construction Cost
Design Percentage
60%
50%
40%
30%
20%
10%
%
0
5
10
15
20
25
30
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency D
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.3586
N = 47

Streets - All Classifications

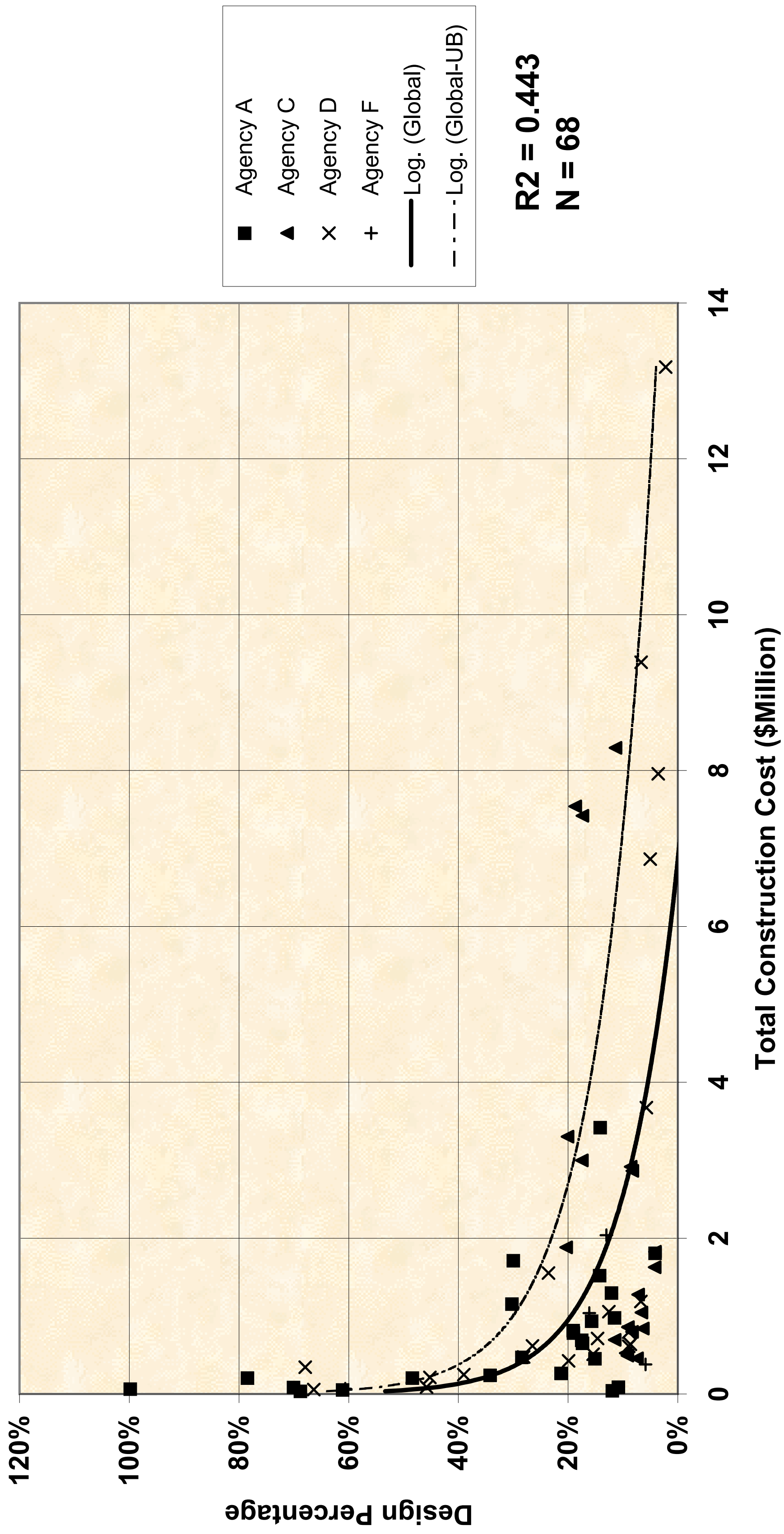
Design Percentage Versus Total Construction Cost



* Two Curb Ramp projects had zero design costs and were excluded from this graph

Pipe Systems - All Classifications

Design Percentage Versus Total Construction Cost



Curve Group II

Construction Management Cost/ Construction Cost Versus Construction Cost:

Municipal Facilities:

In general, the patterns of the regression models are more or less similar to the Design% graphs. The trends, in general, are good. However, R^2 values are very low (<=0.4613). This indicates a wide scatter of CM% around the regression model. With the exception of one library project with a CM% of 28%, all CM% values are smaller than or in the neighborhood of 20%. Most of the outliers are small projects. Projects larger than $8 million make significant contribution to the trend of the model. Additional data on larger projects can significantly improve the global model (page D-48).

In conclusion, construction management curves for Municipal Facilities have significantly smaller R2 compared to Design curves. This indicates that various projects and/or various agencies have different construction management costs. In other words, construction management costs are influenced more than design costs by factors other than project size.

Streets:

The CM% graph is very similar to the Design% graph for Streets projects. Some projects with extremely high CM% (>70%) are the main contributors to the area above the confidence limit. A very large number of small street projects were provided in this study. These are mostly "Renovation / Resurfacing", "Bike / Pedestrian / Curb Ramps", and "Signals". Additional data on larger projects can be very useful. Nevertheless, the above three classifications usually do not have large projects and can hardly contribute to sizes larger than $5 million. This emphasizes the need for segregating the data by project classification, as recommended by the statistical analysis (Appendix B-I, page B-3).

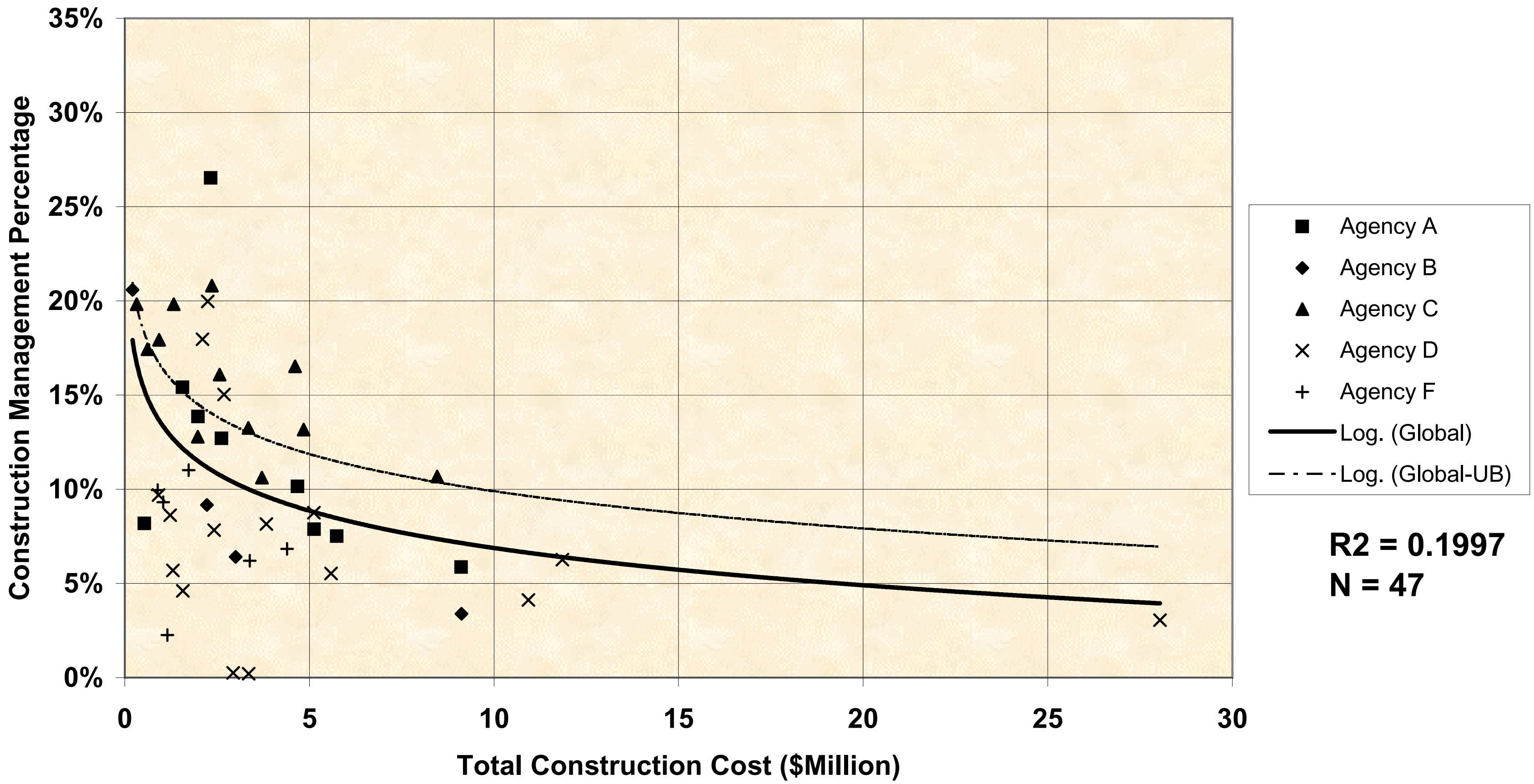
The study concluded that construction management curves for Streets have a reasonable trend, but low R^2 (wide scatter). "Widening / New / Grade Separation" classification has an exceptionally flat slope and a very low R^2 (0.0001) that represents lack of correlation between construction management cost and project size (total construction cost). The wide scatter of data (low R^2) in some classifications can be attributed to the inherent differences among the projects, as explained for Municipal Facilities.

Pipe Systems:

The trends of the regression curves are realistic. There are many small projects with low construction management cost (less than 15% of total construction) and a few small projects with high construction management costs (greater than 35% of total construction). The global R^2 value is higher than Municipal Facilities and Streets. This indicates less influence by factors other than project size. The R^2 is much smaller than the Design%. Specifically, "Pump Stations" classification has a very high R^2 value (0.6430). However, this value is not reliable due to the very small number of "Pump Station" projects. To conclude, the Pipe Systems project type has a better model than the other two project types. Additional data collection should concentrate on medium size projects ($2 million to $8 million) in all classifications and large projects in "Pump Stations" and "Pressure Systems".

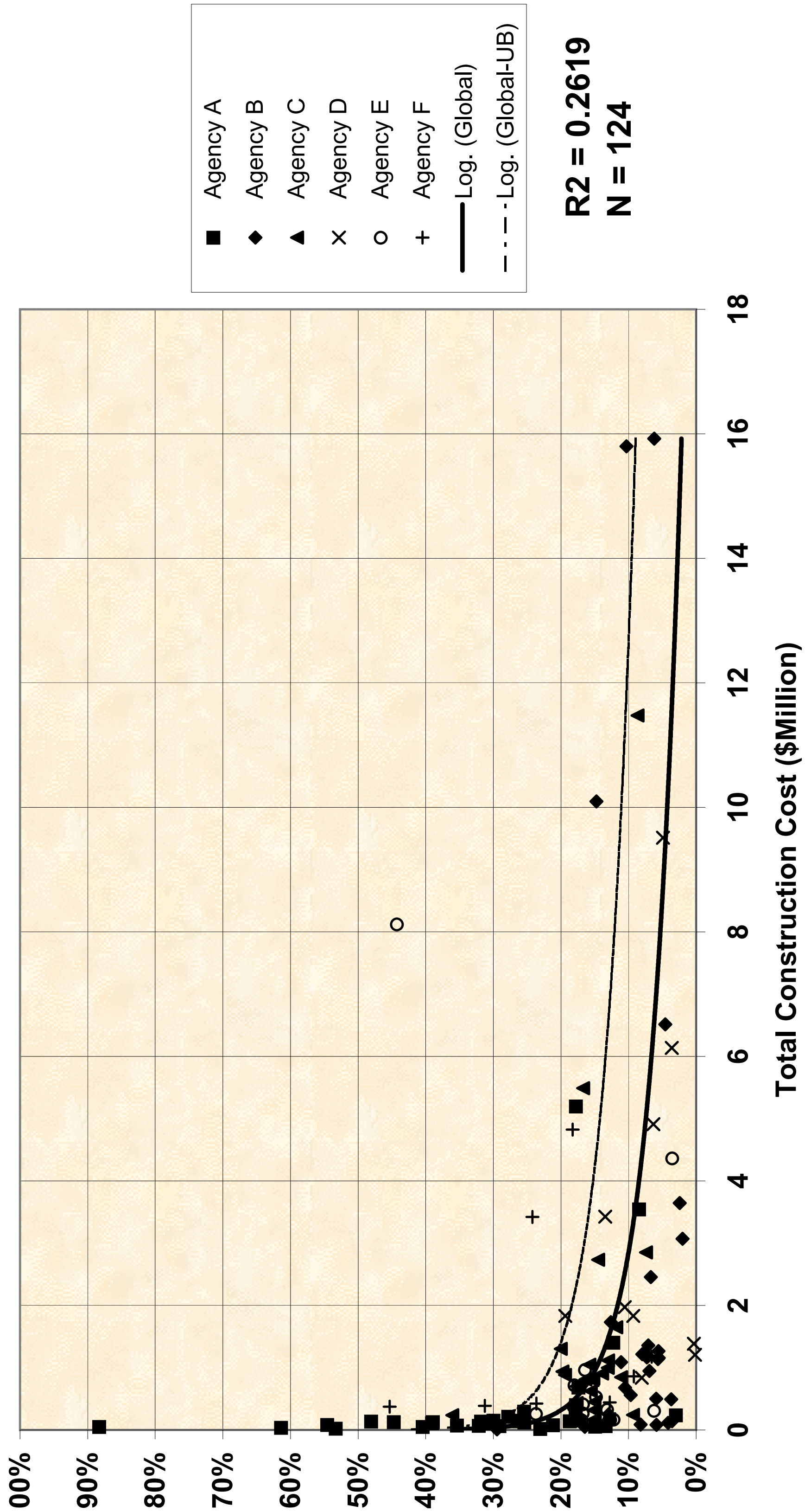
Municipal Facilities - All Classifications

Construction Management Percentage Versus Total Construction Cost



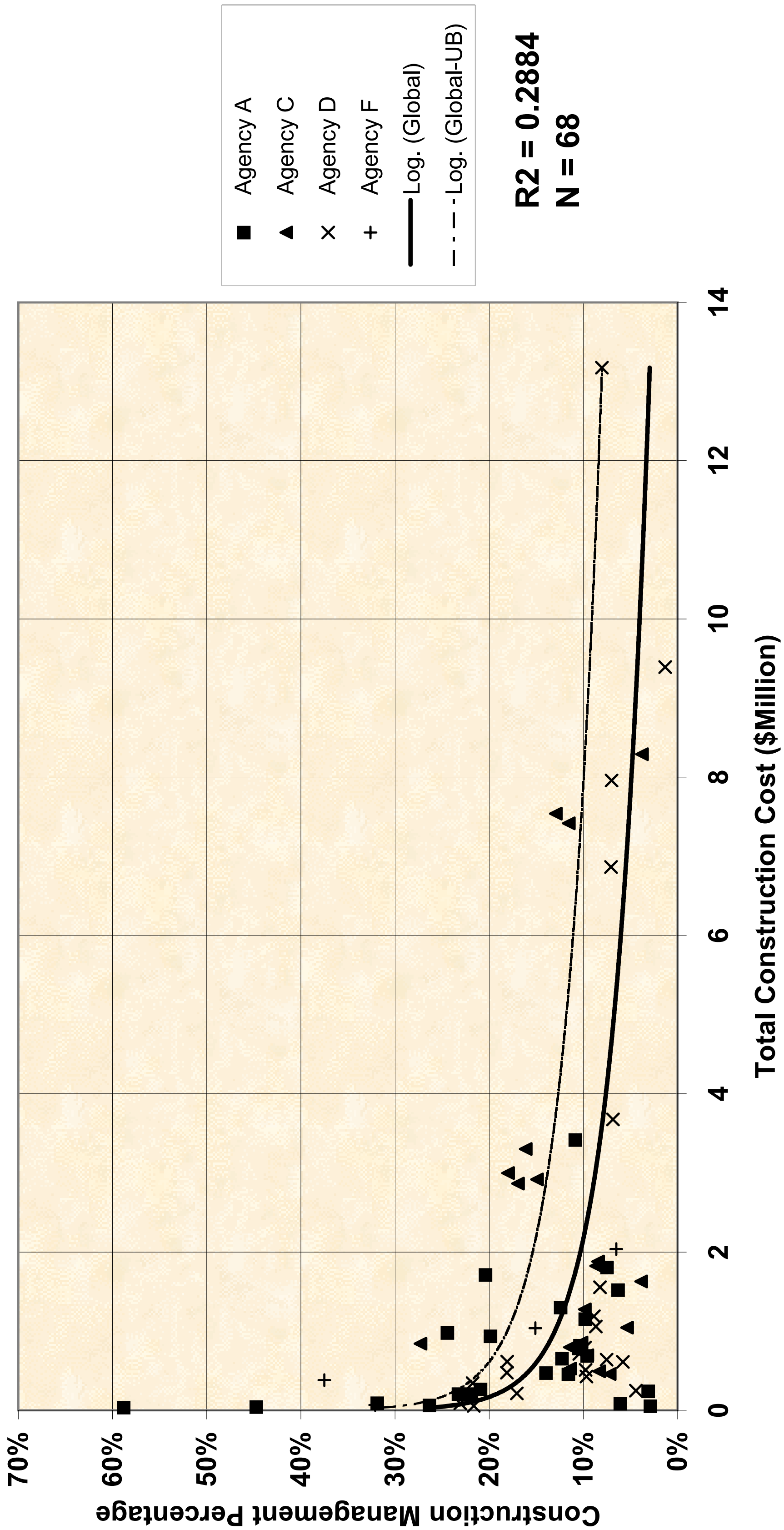
Streets - All Classifications

Construction Management Percentage Versus Total Construction Cost



Pipe Systems - All Classifications

Construction Management Percentage Versus Total Construction Cost



Curve Group III

Project Delivery Cost / Construction Cost Versus Construction Cost

Municipal Facilities:

The project delivery model for Municipal Facilities has a realistic trend. Projects are relatively well distributed around the regression curve. The relatively high numbers of smaller projects reduces the R^2 value (0.4228).

Streets:

The general trend of the model is good. A large number of small projects are clustered at lower left corner of the graph. This indicates the need for additional data collection on projects larger than $2 million. The low value of R^2 for Streets project type is attributed partially to the clustering of small projects and partially to the two Street projects with very high project delivery costs (above 100% of construction cost).

Pipe Systems:

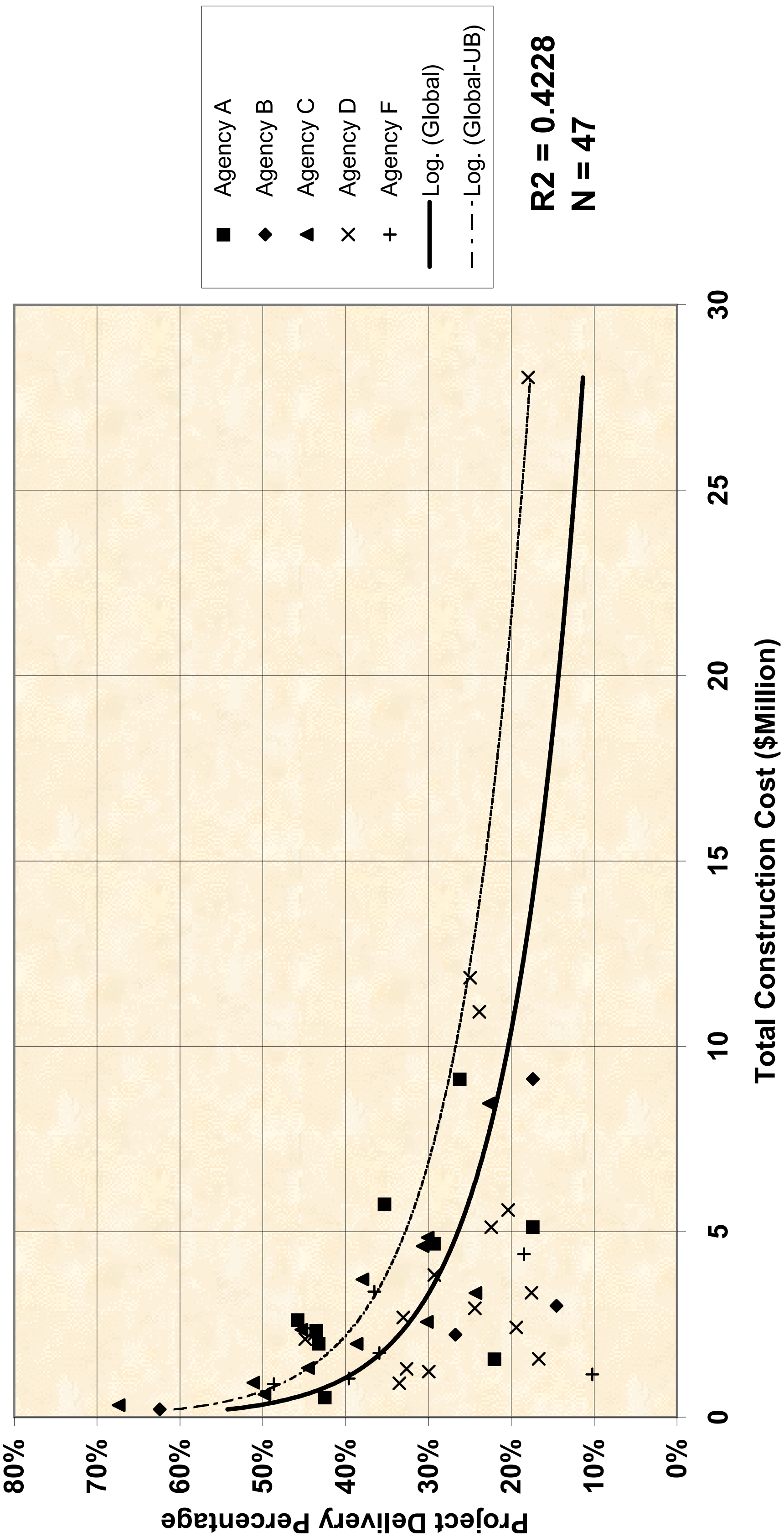
The Pipe Systems project type also has a good general trend and the R^2 value is relatively high. Similar to Streets, additional data on projects larger than $2 million can significantly improve the model.

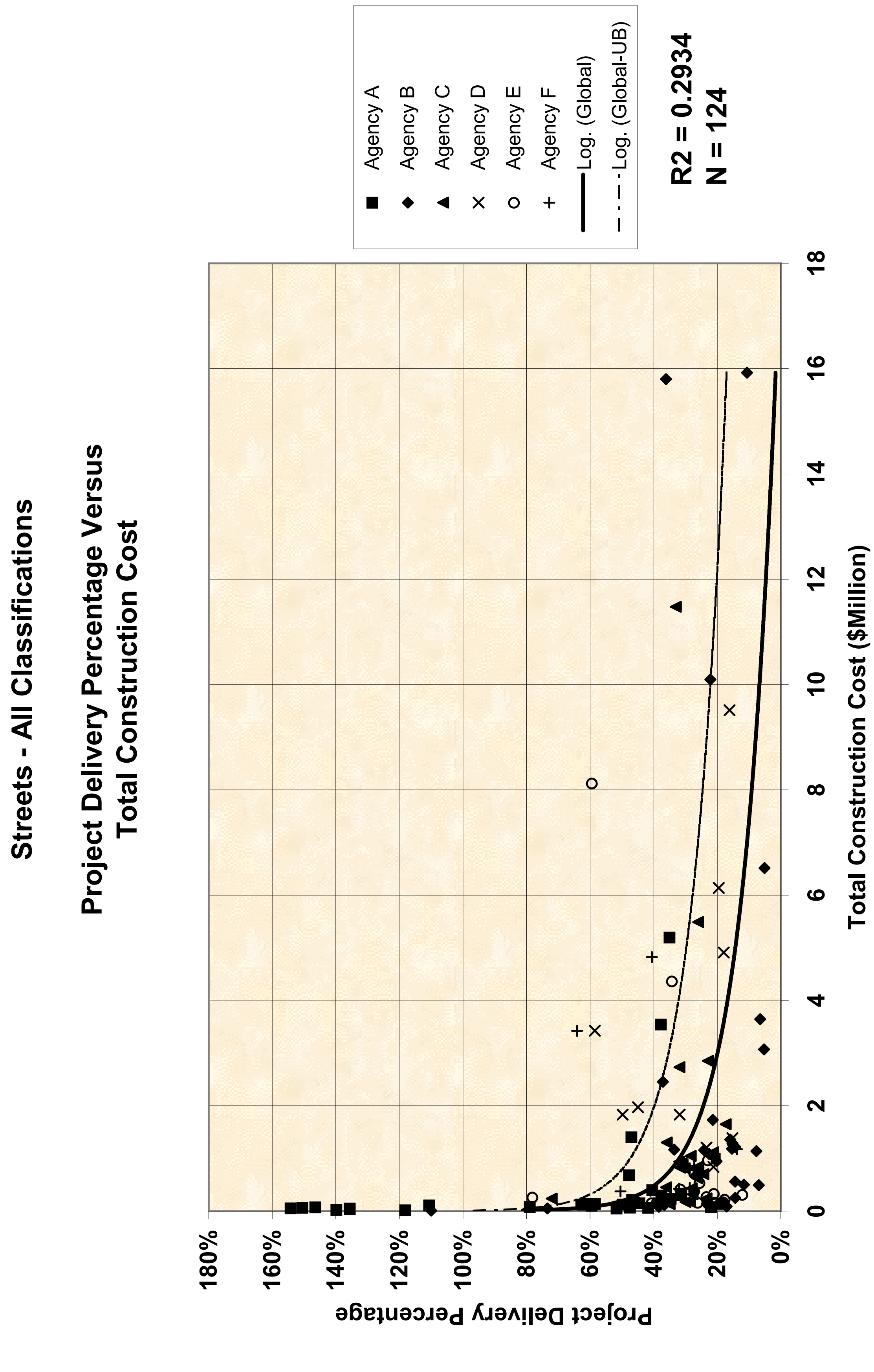
General Comments:

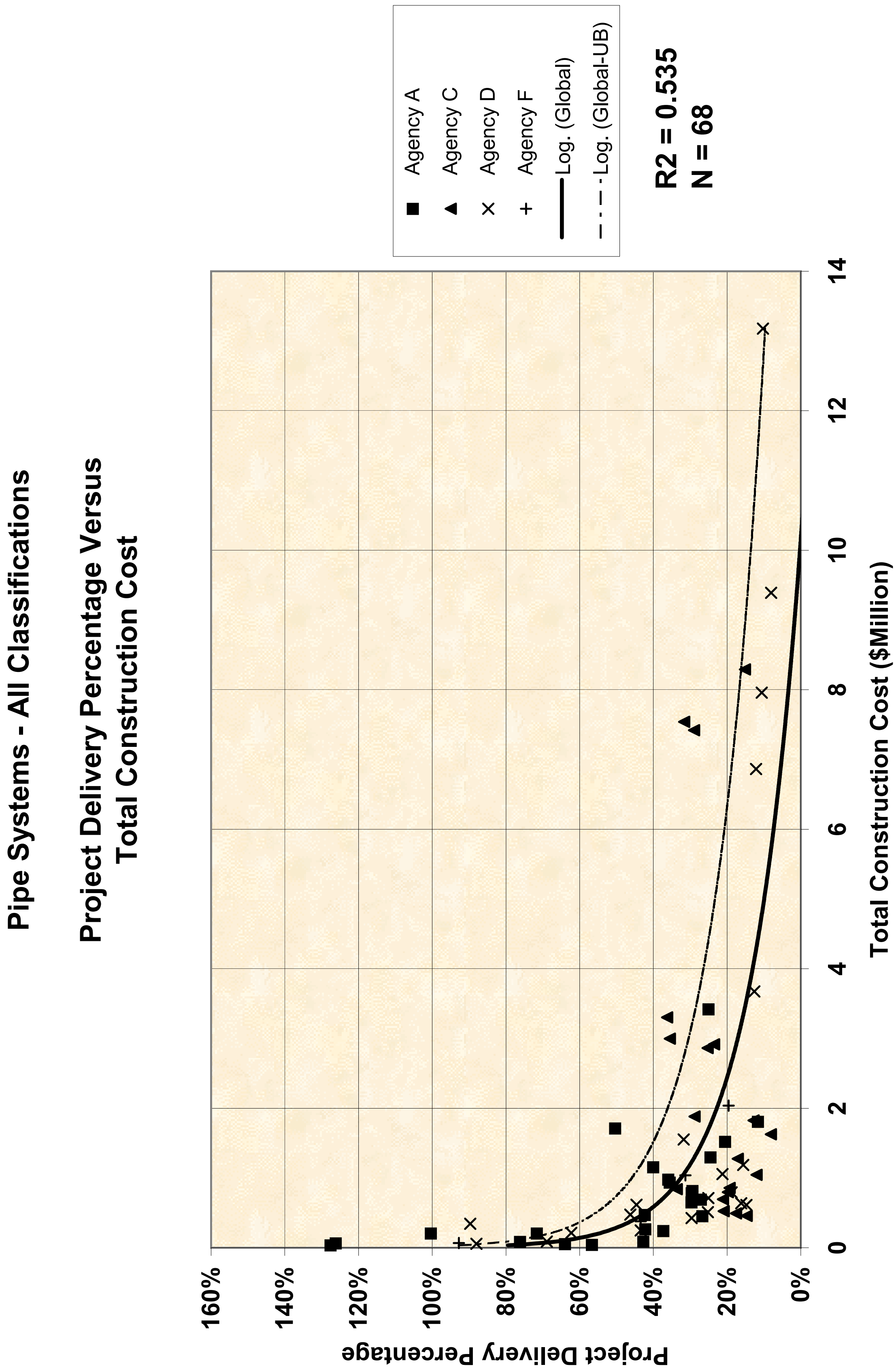
The Pipe Systems project type shows the highest R^2 value (0.5350) and Streets project type has the lowest (0.2934). In general, the Municipal Facilities project type presents low project delivery costs, whereas Streets and Pipe Systems show similar values and trends, higher than Municipal Facilities. These curves also confirm the need for collecting information on large projects (>$4 million), especially for Streets and Pipe Systems.

Municipal Facilities - All Classifications

Project Delivery Percentage Versus Total Construction Cost




Streets - All Classifications
Project Delivery Percentage Versus
Total Construction Cost
Project Delivery Percentage
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
0
2
4
6
8
10
12
14
16
18
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency D
Agency E
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.2934
N = 124


Pipe Systems - All Classifications
Project Delivery Percentage Versus
Total Construction Cost
Project Delivery Percentage
160%
140%
120%
100%
80%
60%
40%
20%
0%
0
2
4
6
8
10
12
14
Total Construction Cost ($Million)
Agency A
Agency C
Agency D
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.535
N = 68

Curve Group IV

Change Order Cost / Construction Cost Versus Construction Cost:

Based on the following Change Order graphs, it appears that the Change Order models are not appropriate for forecasting purposes. The regression curves are either flat or slightly ascending and there is an extremely wide scatter of data around the regression curve. The very small R^2 values (0.0365-0.0013) indicate that no predictions can be made from the Change Order Costs regression curves and using these curves as a predictive tool is not recommended. More data on large projects should be collected and some of the small projects that are outliers need to be revisited and, perhaps, eliminated. No conclusive remarks can be made at this time other that the observation that there is no correlation between Change Order % and total construction cost.

Curve Group V

Total Project Duration Versus Construction Cost:

Comparison of the three project types graphs shows that the Municipal Facilities project type has a more realistic trend: larger projects take longer to build. In the Pipe Systems and Streets categories, on the other hand, total durations remain constant (or even decrease) as project sizes increase. This discrepancy is partially due to the outliers; the small projects (less than $1 million total construction cost) with considerably large total duration (more than 200 months). This effect is more significant for Streets due to larger number of outliers.

In general, the data points show large scatters around the regression curves and have very small R^2 values (<0.2). Almost no correlation can be made between Projects durations and their total construction costs for Municipal Facilities (R^2=0.0621) and Streets (R^2=0.088). The Pipe Systems model shows a slightly better fit to the data points (R^2=0.1912). No conclusive remarks can be made unless additional data is collected and the outliers are eliminated.

Table P – Performance Graphs R^2 Results

Project Type/ Project Classification	Design % vs Construction Cost	Construction Management % vs Construction Cost	Project Delivery % vs Construction Cost
Municipal Facilities	**0.3586**	**0.1997**	**0.4228**
Libraries	0.6544	0.2253	
Police/ Fire Station	0.1384	0.1041	
Community Building / Recreation Center/ Children Center / Gymnasium	0.5689	0.4613	
Streets	**0.1755**	**0.2619**	**0.2934**
Widening / New / Grade Separation	0.2129	0.0001	
Bridge (Retrofit / Seismic)	0.5038	0.2233	
Renovation / Resurfacing	0.0221	0.6387	
Bike / Pedestrian / Curb Ramps	0.6382	0.3613	
Signals	0.0320	0.0668	
Pipe Systems	**0.4430**	**0.2884**	**0.5350**
Gravity System (Storm Drains, Sewers)	0.4929	0.3577	
Pressure Systems	0.2100	0.1630	
Pump Station	0.1988	0.6430	

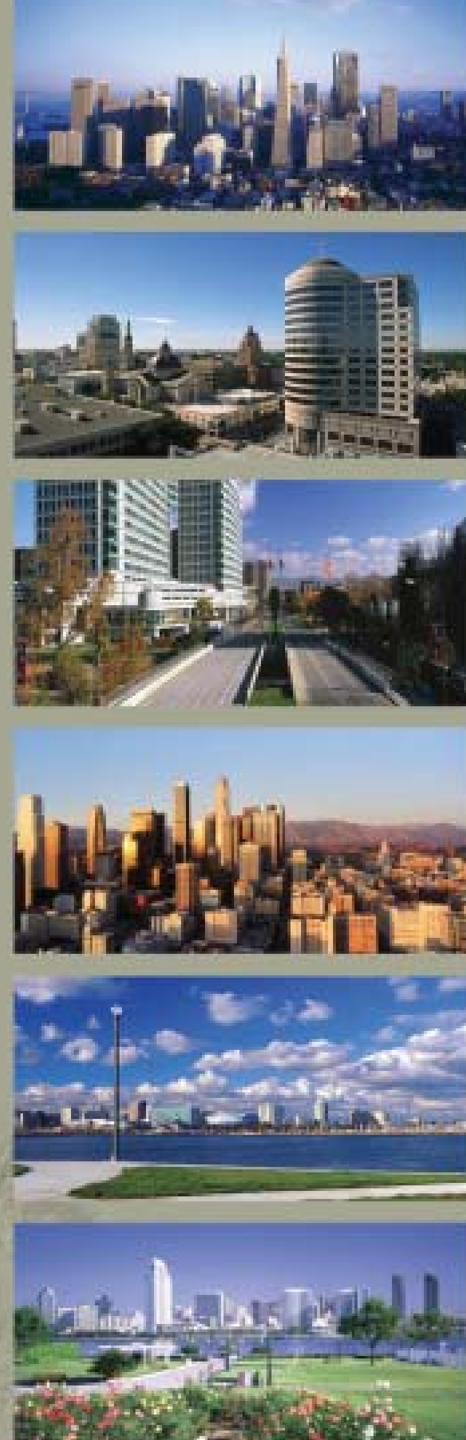
Table Q – CIP Delivery Costs*

Project Type/ Project Classification	Total Construction Cost (TCC)	Design Cost TCC	Construction Management Cost TCC	Project Delivery Cost TCC
Municipal Facilities	**TCC< $0.5M**	**35% - 50%**	**17% - 19%**	**48% - 55%**
	$0.5M<TCC<$ 3M	**25% - 44%**	**12% - 15%**	**35% - 42%**
	TCC> $3M	**19% - 37%**	**9% - 12%**	**28% - 35%**
Libraries	TCC< $0.5M	38% - 43%	22% - 27%	
	$0.5M<TCC<$ 3M	26% - 32%	17% - 21%	
	TCC> $3M	20% - 24%	11% - 16%	
Police/ Fire Station	TCC< $0.5M	23% - 28%	12% - 14%	
	$0.5M<TCC<$ 3M	19% - 23%	10% - 12%	
	TCC> $3M	16% - 21%	8% - 11%	
Community Building / Recreation Center / Children Center / Gymnasium	TCC< $0.5M	38% - 43%	16% - 18%	
	$0.5M<TCC<$ 3M	28% - 32%	11% - 13%	
	TCC> $3M	20% - 25%	8% - 11%	
Streets	**TCC< $0.5M**	**30% - 40%**	**20% - 28%**	**45% - 61%**
	$0.5M<TCC<$ 3M	**19% - 35%**	**12% - 20%**	**32% - 47%**
	TCC> $3M	**19% - 35%**	**N/A**	**N/A**
Widening / New / Grade Separation	TCC< $0.5M	28% - 32%	12% - 17%	
	$0.5M<TCC<$ 3M	20% - 25%	12% - 17%	
	TCC> $3M	16% - 21%	12% - 17%	
Bridges (Retrofit / Seismic)	TCC< $0.5M	60% - 80%	18% - 23%	
	$0.5M<TCC<$ 3M	32% - 55%	14% - 19%	
	TCC> $3M	19% - 40%	12% - 17%	
Renovation / Resurfacing	TCC< $0.5M	12% - 18%	20% - 25%	
	$0.5M<TCC<$ 3M	11% - 17%	13% - 18%	
	TCC> $3M	11% - 17%	N/A	
Bike / Pedestrian / Curb Ramps	TCC< $0.5M	22% - 40%	22%-35%	
	$0.5M<TCC<$ 3M	18% - 35%	5% - 10%	
	TCC> $3M	N/A	N/A	
Signals	TCC< $0.5M	18% - 25%	20% - 28%	
	$0.5M<TCC<$ 3M	15% - 22%	19% - 25%	
	TCC> $3M	N/A	N/A	
Pipes	**TCC< $0.5M**	**35% - 42%**	**17% - 22%**	**45% - 62%**
	$0.5M<TCC<$ 3M	**19% - 35%**	**10% - 15%**	**30% - 45%**
	TCC> $3M	**19% - 35%**	**N/A**	**N/A**
Gravity System (Storm Drains, Sewers)	TCC< $0.5M	35% - 50%	17% - 22%	
	$0.5M<TCC<$ 3M	20% - 35%	12% - 18%	
	TCC> $3M	N/A	N/A	
Pressure Systems	TCC< $0.5M	18% - 23%	16% - 19%	
	$0.5M<TCC<$ 3M	14%-17%	13% - 16%	
	TCC> $3M	N/A	N/A	
Pump Station	TCC< $0.5M	N/A	N/A	
	$0.5M<TCC<$ 3M	15% - 17%	17% - 19%	

* The values in this Table provide an overall summary of the performance benchmarking results. Caution is necessary in using this information as a predictive tool. Additional data, at future phases of this study, will significantly improve this Table and may provide a basis for more accurate forecasting.

Chapter 7

Conclusions and Recommendations



CHAPTER 7 Conclusions and Recommendations

A. PROCESS BENCHMARKING: "RECOMMENDED BEST MANAGEMENT PRACTICES"

The process benchmarking phase of this study proved to be a unique and pro ductive opportunity for senior responsible personnel from six of the larger cities in California to discuss and evaluate their project delivery methods. Project team members are committed to continuing this dialogue into future study phases to expand the knowledge base and improve project delivery performance.

The general purpose of process benchmarking was to identify the best management practices that are common among the agencies and recommend the best management practices that can significantly improve delivery of capital projects on time, within budget, and to the client's satisfaction.

Each agency was able to compare what worked for them and gain insight into what worked for other agencies. The most surprising part of the study was the similarities, not the differences, among agencies. Government agencies are constrained by similar sets of laws and regulations regarding land acquisition, environmental review, consultant hiring, public bidding, and social policies. The differences occur primarily in the degree of flexibility provided by local governing bodies to Directors of Public Works/City Engineers. Each agency makes its own decisions about the degree and type of oversight provided.

Conclusions of the process benchmarking study are:

- 24 processes are recommended as the best management practices that are beneficial to all agencies for delivering Capital Improvement Projects. These processes are listed in Chapter 1 as well as Chapter 5 of this report.
- 15 processes were identified the best management practices that are commonly implemented by all participating agencies, at some level. Similarities among participating agencies may provide a rationale for aggregating project information into one regression model, despite statistical limitations.
- "Consultant Selection and Usage" and "Design" are the most commonly implemented practices. The recommended best management practices in the "Planning Processes" category have good potential for implementation and improvement.

B. PERFORMANCE BENCHMARKING

The performance regression curves for delivery costs fell within ranges that appeared both reasonable and predictable, based on the collective experience of the project team. Consensus was reached on the following conclusions and recommendations regarding the performance curves:

Design Cost Conclusions

The percentage of design costs, as a percentage of construction costs, decreased as the size of project increased. This is understandable due to the many fixed activities that must be done to plan, design, bid, and award a project regardless of the size.

Design costs curves variance was the least in Municipal Facilities projects with respect to variations in total construction costs, compared to the other two project types (Streets and Pipe Systems). *The project team concluded that this was consistent with their experience that larger buildings require proportionally greater design detail, resulting in increased design costs. An exception to this is when the building is a repetitive multi-story structure.*

The repetitive nature of details and typical sections found in most Street projects influences the design costs for this type of project. Design costs on larger projects reduce predictably because of this repetitiveness.

The Pipe Systems model showed the most dramatic decline in the design costs as a percentage of total construction costs, as the total construction costs increased. The project team concluded that this was consistent with their experience that underground work such as pipe systems require extensive research on existing utilities and other possible interfering structures and that this research time is not always proportional to the size of the project (i.e. utility information for an entire block can be researched and plotted as easily as just an intersection).

Construction Management Cost Conclusions

Construction management costs as a percentage of total construction costs decreased with the increasing sizes of the projects (total construction costs). The project team concluded that fixed costs associated with requiring construction reports and project accounting would account for the lower percentages on the larger projects.

In the Streets project category, construction management costs as a percentage of total construction cost varied the most with changes in total construction costs. The project team concluded that this is due to costs related to materials testing, compaction reports, traffic controller testing, and other related activities that would not change proportionately with respect to project size.

Total Project Delivery Cost Conclusions

Total project delivery cost is expected to run between 10% and 62% of the total construction cost. Variations for different project types can be explained by the previous discussions on design and construction management costs as percentages of total construction costs.

Conclusions about Change Order Costs

The benchmarking models for change order costs as a percentage of total construction costs versus construction costs did not prove effective. No conclusions can be made other than the need for additional data collection and identification and elimination of outliers, as discussed in Chapter 6, Page 41.

Conclusions about Project Duration

The regression models for total project durations did not provide much information other than the need for additional data collection the elimination of outliers (refer to Chapter 6 – Page 41 for detailed discussion).

C. STUDY QUALIFICATIONS AND CHARACTERISTICS

The *California Multi-Agency CIP Benchmarking Study* has developed a solid and beneficial foundation for process and performance benchmarking. Throughout this report it has been noted that additional project data will further improve the study. The statistical analysis showed that it is inappropriate to bundle project data from project classification level to project type level, based on the current data range. Ideally, the study should include at least 10 projects in each category (project classification), for each agency. About 50% of these projects should be new construction and the remaining should be rehabilitation or renovation projects".

Analysis of the project indexing study also confirmed that additional data collection is required. It also identified "Data Gaps" and the scope of needed additional data collection (Appendix B-IV, page B-24). Projects smaller than $100,000 and greater than $10,000,000 significantly influence the trend of the regression curves portrayed within this phase of the study. The regression curve is expected to improve significantly with the addition of data (e.g. the design percentage should never go to zero). In conclusion, the above discussion suggests the following:

- Individual agencies can benefit from using the current performance curves as "comparative" tools rather than "predictive tools". The best use of these curves, with the current data, is to compare an agency's performance to industry trends.
- Additional project data will improve the results of this study and its ability to predict resource requirements to deliver a Capital Improvement Project. The current performance curves provide a good snapshot of industry performance and, without standardization, these curves may be used to roughly forecast project delivery resource requirements.
- Areas of additional data collection, as identified by the statistical analysis, include:
    - *At least 10 projects per classification are needed. This number should be tripled (due to the three complexity categories) which results in 2,000 projects, of which 1,000 would be new construction and 1,000 rehabilitation to make the best use of the complexity indices.*
    - *Collect more "Complex" and "Simple" Projects, more projects of smaller size, and more "Pipe Systems" Projects with diverse New/Rehab indices*
- At this stage of the study, the project team did not categorize change orders based on their source (Unforeseen and Changed Conditions, Design Changes, Owner-Initiated, Commissioning/Optimization, Miscellaneous). Segregation of these change orders and benchmarking only against "Design Changes" would be a significant improvement to the current study.
- The study found that agencies' multipliers were similar and it was therefore reasonable to use "Costs" as the comparative basis, instead of "Hours". During future phases, new participants' multipliers should be compared in order to determine if the continued use of the "Costs" approach is appropriate.

In the process questionnaire, the selection of scale is subjective. The definition of the (0-5) scale was based on the project team's experiences and expertise rather than performance outcomes. Individuals' perception identified 0 as meaning "weak" and 5 as meaning "strong". For example, it may be believed that implementation of "Web-based Project Controls System" is a best management practice and an agency with a score of 5 for this question is assumed to have a good performance. In reality, that may or may not be the case.

We can conclude that the following modifications to the process benchmarking may be useful at future phases of this study:

- *It would be helpful to link processes to performance. In order for that to occur, the process data should be collected in the same time frame as the performance data and, therefore, they should be project specific.*

- *Process questions should be expertly designed to be objective and presented in random order, without any pre-assumptions for "good" and "bad" management practices. The questions should not communicate the meaning of "strong" or "weak" to the respondents to minimize data biases.*

D. NEXT STEPS

- This study builds the foundation of a continuous benchmarking study. The results of the performance curves can be improved by additional data. Various sources of discrepancy and bias were identified and accounted for during data collection and analysis (e.g. variations in agencies' labor cost multipliers, differences in work breakdown structures, possible effects of projects indices, and projects that are not representative of agencies' standard processes).
- Areas and scope of additional data collection were identified in this study. During the next phase, additional data collection will be an important task.
- The difficult task of defining the salient characteristics of "complex" and "simple" projects should be an early step in future phases of the study.
- Delivery costs associated with consultants' services can be distinguished from in-house delivery costs and a comparison can be conducted between in-house delivery and the usage of consultants in future studies.
- A user interface form can be used to update the project database. As project information is compiled into the project database, performance data will be updated automatically and the performance curves can be generated. In addition, the database can be enhanced to account for elimination of outliers, provide intelligent recommendations for betterment of project selection as well as output analysis, and generate various reports.
- Linking processes to performance is a useful task to perform in future benchmarking studies. The process information can also be added to the project database and the system can be programmed to find correlations among processes and various performance parameters and provide intelligent conclusions and recommendations.

Acknowledgments

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Appendices

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CITY OF SAN JOSE CAPITAL OF SILICON VALLEY

CITY OF LONG BEACH

A-I. Briefing Paper

City of Los Angeles
Bureau of Engineering

MULTI-AGENCY BENCHMARKING STUDY BRIEFING PAPER

Introduction

The City of Los Angeles, Bureau of Engineering is proposing a multi-agency Benchmarking study to compare the costs and processes associated with the delivery of capital improvement projects. This briefing paper is prepared to solicit agency participation, to identify the project goal, to provide a summary of the scope of work, and to provide a preliminary schedule to achieve the project goal within the defined scope.

Project Goal

The purpose of this project is to provide a general analysis of the efficiency of capital project delivery systems within several agencies in California. Seven city agencies have been preliminarily identified for participation. Three types of projects proposed to be included in the study are: Streets, Wastewater, and Municipal Facilities (Buildings). Each agency will be asked to supply data from 8 to 10 completed projects within each project type.

Performance and process benchmarks will be defined. Performance Benchmarking involves the development of comparative cost data on projects within each agency. The proposed measure of efficiency will be the hours expended on each phase compared to cost of construction. As an example, hours expended on design will be compared and contrasted with total construction cost. Process Benchmarking focuses on the project management and business practices for delivering the projects. The goal of this study is to define processes, to arrive at a general measure of comparative performance, and then to link the processes to the measured performance.

Scope of Work

As noted above, three (3) project types will be investigated in this study: Streets, Wastewater, and Municipal Facilities (Buildings). The project participants that are proposed include seven (7) major cities in the State of California: Long Beach, Sacramento, San Diego, San Francisco (Department of Public Works), San Francisco (Public Utility Commission), San Jose, and Los Angeles. Two representatives from each city will be asked to participate in this study. The representatives are expected to be "Full" Engineers or higher positions within the agencies, with a senior manager (Department Manager or Director position) serving in an oversight capacity.

Cost information for each project phase will be collected and analyzed. Five (5) phases are defined at this time: Pre-design, Design, Bid & Award, Construction, and Post-construction. The number of phases, however, may be narrowed down to three, Pre-Design, Design, and Construction, depending on availability of information.

Between eight and ten projects per category, per city, will be studied. All data will be compiled into a database and various comparison reports and/or correlation analyses will be generated for the purpose of this study. Additional Benchmarking data from previous Benchmarking studies will be incorporated as appropriate.

Project Plan and Schedule

Monthly meetings will be held to facilitate data collection, data compilation, and trend analysis between process benchmarks and performance benchmarks.

- Monthly Meetings: Meeting schedules and their tentative agendas are tabulated below. At least one representative per participating agency is requested to participate in the monthly meetings. The senior management representative should attend the first meeting in order to get agency "buy-in" on the project. The "Full" Engineer position should also attend the first meeting and subsequent meetings thereafter. The City of Los Angeles will also create the database and enter data provided by all participants into the database for analysis.

- It is proposed that the locations of the meetings would alternate between Los Angeles and Sacramento.

Meeting #	Date	Agenda
1	December 19, 2001	Presentation by each agency Finalize selection of project types (Areas) Confirm agencies participation Determine required level of effort and resource requirements. Identify benchmarks and define questionnaires preparation criteria
2	January 10, 2002	Review, refine, and finalize questionnaires Estimate data collection scope and requirements
3	February 12, 2002	Finalize data collection criteria Define database design criteria Initiate data collection
4	March 14, 2002	Progress Report Present preliminary data Discuss data collection problem areas
5	April 11, 2002	Finalize data collection Discuss data compilation and analysis process
6	May 9, 2002	Finalize Database and data analysis Prepare and present draft graphs and tables using real data collected through questionnaires Report planning approach and strategy
7	June 13, 2002	Prepare and submit draft report Finalize database tables, graphs, and forms
8	July 11, 2002	Submit final report and database

- The process topics will be defined based on the input provided by the agencies' participants in the meetings and through the resultant questionnaire. The process questionnaire will be designed to gather information about agencies' procedures and their processes to initiate, perform, and close out a project. For example, availability of Training Programs, consultant procurement and usage, and procedures manuals are process questions.

- Performance data about the projects, such as cost variance information, will be collected from the agencies for comparison.

- A Microsoft Access database will be developed and used to compile the project information into the computer and to perform the detailed analysis. Performance and process benchmarks that are identified in the monthly meetings will be used as a comparison basis in the database.

- The program will generate tabular reports to be analyzed and to conclude comparative efficiency of the selected projects. Trends of all performance parameters versus process parameters will be identified and the success of each agency's capital projects will be compared to and contrasted with other agencies' projects to identify success and hindrance symptoms and their causes.

Outputs

This study will provide tabular and/or graphic reports depicting trends among various performance and process benchmarks. The following are some example reports:

- Planning hours versus construction costs
- Design hours versus construction costs
- Construction Management hours versus construction costs
- Total project hours versus construction costs
- Change Order percent versus construction costs
- Ratio of consultants to in-house engineers versus construction costs

These reports will then be reviewed and the probable relationships between processes and project performance identified. The final results will be published with all data presented anonymously. The greatest value of the data is that it will stimulate thought process among the agencies, allowing each agency to find ways to improve its own processes.

Deliverables

- A short report with brief explanation of process and performance benchmarks and their correlations, data analysis, and final recommendations and conclusions. The final report will explain the team's approach to:

  Define suitable process and performance benchmarks and their relationships
  Identify Best Practices in capital projects and lessons learned
  Provide recommendations to improve performance of such projects, effectively and economically.

- A Database program, containing collected data and generated reports.

A-II. Administrative Items Information

Agency	Fringe Benefits	Compensated Time Off	City Overhead	Department Overhead	Agency Overhead	Indirect Rate Factor[1]	Entity Receives General Fund Support For Projects (YES/NO)
City of Long Beach Department of Public Works	38.60%	19.40%	4.40%	11.90%	72.70%	147.00%	YES
City of Los Angeles Department of Public Works/ Bureau of Engineering	15.76%	18.67%	26.07%	26.28%	57.94%	144.72%	YES
City of Sacramento Department of Public Works	30.00%	18.70%	27.82%	5.76%	66.41%	216.43%	YES
City of San Diego Public Buildings & Parks / Field	27.70%	15.50%	12.00%	33.10%	4.00%	92.40%	NO
Transportation & Drainage Design / Field	27.70%	14.70%	47.90%	39.40%	4.60%	134.20%	
Water / Wastewater Facilities / Field	27.50%	13.50%	11.90%	53.60%	4.30%	110.80%	
City and County of San Francisco Department of Public Works / Bureau of Engineering / Bureau of Construction Management / Bureau of Architecture	20.97%	22.37%	15.02%	26.41%	66.25%	136.00%	NO
City of San Jose Department of Public Works	26.79%	25.00%	40.86%	13.00%	INCLUDED	148.00%	NO

(1) This value may be different from the Summation of the overhead values. The compounding formula is different for different Agencies.
(2) Not included in the Indirect rate because it is not charged to these projects

FRINGE BENEFITS

City of Long Beach	City of Los Angels	City of Sacramento	City of San Diego	City and County of San Francisco	City of San Jose
• Deferred comp (city contribution) • FICA Medicare • Health, dental, life insurance • Payroll Admin • Retirement pension • Worker's Comp	• Dental Insurance • Employee Assistance • Health Insurance • Hiring Hall Fringe • Life Insurance • Medicare • Pensions (Fire/Police Sworn) • Retirement (Civilians) • Social Security • Unemployment Insurance • Union Sponsored Benefits • Unused Sick/Vacation Payout • Worker's Compensation (PST) (457 Retirement Plan)	• $45 Transportation Allowance • 80% Reimbursed Transit Pass • City-Paid Employee PERS • Disability Insurance Contribution • Life Insurance Contribution • Medical/Dental Ins Contribution	• FICA/Medicare Insurance • Flex Benefits Plan • LT Disability • Retirement • Risk Management Admin • Unemployment Insurance • Unused Sick Leave • Workers Comp Insurance	• Dependent Coverage • Flexible Benefit Package • Health Services – City Match • Long-Term Disability Insurance • Retirement Pick-Up • Social Security – Medicare • Social Security (OASDI) • Unemployment Insurance	• Concern • Dental Insurance • Health Insurance • Legal • Life Insurance • Medicare • Retirement • Salary Continuation • SSN • Unemployment • Uniform • Unused Sick / Vacation Payout • Vision Insurance

COMPENSATED TIME OFF					
City of Long Beach	**City of Los Angels**	**City of Sacramento**	**City of San Diego**	**City and County of San Francisco**	**City of San Jose**
• Bereavement • Holiday • Jury Duty • Sick leave • Union leave • Vacation	• Bereavement Leave • Family Illness • Floating Holiday • Holiday • Injury on Duty • Jury Duty • Military Leave • Preventive Medicine • Sick Leave • Vacation • Workers' Compensation	• 10 Days Mgmt Leave • 10 Vacation Days • 12 Sick Days • 12 to 14 Holidays	• Accident Prevention Mtgs. • Annual Leave/Pay in Lieu • Annual Leave/Sick Family • Annual Leave/Sick Personal • Annual Leave/Vacation • Cash Bonus • City Civil Service Exams • City Health Wellness Program • City Job Interviews • City Medical Exams • Comp Time Hours Taken • Court Leave - Jury Duty • Court Leave - Witness Duty • Discretionary Leave • Exceptional Performance Pay - EPP • Floating Holidays • Grievance Processing • Holiday Credit on Day Off • Holidays - Scheduled • Industrial Leave • In-Service Training • Labor Relations Meeting • Seminars and Conferences • Sick Leave Old/Personal • Termination Pay • Voluntary Leave - Paid	• Associated mandatory fringe benefits • Compensatory time off • Holiday pay • Sick pay • Vacation	• Disability Leave • Executive Leave • Funeral Leave • Holiday Leave • Jury Duty • Military Leave • Paid Time Off • Personal Leave • Sick Leave • Vacation • Witness Leave

CITY OVERHEAD					
City of Long Beach	**City of Los Angels**	**City of Sacramento**	**City of San Diego**	**City and County of San Francisco**	**City of San Jose**

• City Attorney
• City Auditor
• City Clerk
• City Manager Legislative
• Financial Management
	• Building Leases (GSD & Spec. Funds)
	• Building Use Allowance
	• Computer Assets Depreciation (Items costing $5,000 & above)
	• Communications Lease (Telephone bill)
	• Equipment Use Allowance (Items costing $5,000 & above)
	• Equipment Exp. Under $5,000 (Computers & equipment costing under $5,000)
	• Emergency Operations Expenses
	• Natural Gas Utility (GSD)
	• Insurance on bond financed assets
	• General City Purposes
	• Liability Claims
	• Petroleum Products (GSD)
	• Vehicle Depreciation
	• Water & Electricity
		City Wide Support Functions such as:
		
		• Accounting
		• Budget
		• Central Copy/Stores
		• City Attorney
		• City Clerk
		• City Computer Support
		• City Manager
		• Etc.
		• Finance
		• IT Administration
		• Payroll
		• Procurement
		• Revenue
		• Telecommunications
			Departmental Support Costs:
			
			• Citizens Assistance
			• City Attorney
			• City Auditor & Comptroller
			• City Clerk
			• City Manager
			• City Treasurer
			• Citywide Dept (includes Liability claims)
			• Financial Management
			• Intergovernmental Relations
			• Personnel
			• Purchasing
				• Board of Supervisors - Budget Analyst
				• Building Repair
				• Building Use Allowance
				• City Attorney
				• Civil Service Commission
				• Controller's Office – Administration
				• Controller's Office – Audits
				• Controller's Office – Operations
				• Controller's Office – PPSD
				• General City Responsibility
				• Health Services – General Fund
				• Human Resources
				• ISD – General Fund subsidy
				• Mayor's Budget Office
				• Purchasing
				• Purchasing – Central Shops
				• Purchasing – Repro/Mail
				  • Real Estate
				  • Worker's Compensation
					Support Services including:
					• Building Occupancy
					• Cafeteria
					• City Attorney
					• City Auditor
					• City Clerk
					• City-wide Programs
					• Civil Service Commission
					• Departments of City Manager
					  o Budget Office
					  o Economic Development
					  o Emergency Services
					  o Employee Relations
					  o Equality Assurance
					  o Quest Partnership
					• Equipment Use
					• Finance
					• General Services
					• Human Resources
					• Independent Police Auditor
					• Information Technology
					• Mayor & Council
					  • Planning Commission

DEPARTMENT OVERHEAD					
City of Long Beach	**City of Los Angels**	**City of Sacramento**	**City of San Diego**	**City and County of San Francisco**	**City of San Jose**
• Accounting • Budget Management • Contract processing Council correspondence • Personnel Admin	• Accounting staff • Budget staff • Clerical Staff/word processing staff serving the entire department • Department Management (Gen. Mgr. & Asst. Gen. Mgrs.) • Inventory staff • Payroll staff • Personnel & training staff • Systems Staff • Vehicle maintenance staff (Police & Fire only) • Warehouse/inventory/ stores staff	• Public Works Administration • Public Works Advanced Computer Support	• Depreciation of Buildings • Depreciation of Equipment • Indirect capital outlay • Indirect data processing • Indirect salaries and fringe (DDs, Eng. Admin) • Indirect supplies/services • Indirect utilities • Operation/Maintenance/Rent of Buildings	• Accounting • Claims • Computer Services • Contract Administration • Deputy Director's Office • Director's Office • DPW Training • Finance & Budget • Health & Safety • Personnel & Payroll • Public Affairs	**DPW Administrative Support including**: • Administration Division • Department-wide management tasks such as budget and HR performed by Division managers that is applied to direct labor only • Director's Office • Engineering Services support • Real Estate Division support

AGENCY OVERHEAD					
City of Long Beach	**City of Los Angels**	**City of Sacramento**	**City of San Diego**	**City and County of San Francisco**	**City of San Jose**
• Building rent • Consultants • Fleet services • Phones • Salaries and wages • Technology services	• City Engineer • Deputies • Division Heads • Secretaries/Clerical • Section Supervisors • Senior Engineers	• Division OH Benefits • Division OH Operational Services and Supplies • Division OH Salary	• Assoc. Analyst • Asst. to Director • Director • Exec. Secretary • Sr. Analyst • Sr. Engineer	• Management staff salaries • Clerical staff salaries • Administrative staff salaries • IS support staff salaries • Temporary salaries • Premium/standby pay • Overtime • Associated mandatory fringe benefits • Travel • Training • Membership dues • Entertainment & promotions • Professional services • Rent • Use of employee cars • Local field expenses • Postage • Building maintenance services • Office equipment rental/maintenance • Security services • Materials & Supplies • Professional registration reimbursements • Equipment • Repair of radio equipment • Telephone services • Workers Compensation • Human Rights Commission services • Medical services • Vehicle maintenance • Vehicle fuel • Administer prevailing wage rates • Mail service • Reproduction • Light, heat & power • GIS support cost • Sewer service charge	• NONE

A-III. Multipliers Application

- Translate "Cost" data into "Effort" (No. of Hours):

$$\text{Design Effort} = \left[\frac{\text{Design Cost}}{\text{Base Rate}} \times \frac{1}{(1 + \text{O.H. Factor} / 100)} \right] / (CC + CO) \times \$1M$$

- Example Project:

"AGENCY XXX – PROJECT YYY"

Design Cost = $62,535 CC + CO = $965,167

O.H. Factor = 147.00% Assume Base Rate = $35/Hour

$$\text{Design Effort} = \left[\frac{62{,}535}{35} \times \frac{1}{(1 + 147/100)} \right] / 965{,}167 \times 1{,}000{,}000$$

Design Effort $\cong$ 750 Hours per Million Dollar of Construction

B-I. Level of Data Aggregation

Statistical Analysis of Construction Cost Data

Final Report Submitted To:

Vanir Construction Management

by

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Los Alamitos, CA 90720

(562) 706-2025
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(April 29, 2002)

[1] Dr. Dessouky is an Associate Professor at the Industrial and Systems Engineering Department of the University of Southern California. He has extensive research experience and numerous publications in production and operations management, transportation system modeling and optimization, statistical simulation, and operations research applications to industrial systems.

Project Summary

The purpose of this study is to determine the appropriate aggregation level of the independent variables (the sum of the construction value and change orders) in a regression model predicting % design cost, % construction management cost, and % project delivery cost for six public agencies. There are three "project type" categories: municipal facilities, streets, and pipe systems. Within each project type, there are many "project classifications". They are:

Municipal Facilities

Libraries
Police / Fire Stations
Community Buildings/Recreational Centers/Child Care/Gymnasiums

Streets

Widening / New / Grade Separation
Bridges / Retrofit / Seismic
Renovation/Resurfacing
Bike/Pedestrian/Curb Ramps
Signals

Pipe Systems

Gravity Systems (Storm Drains, Sewers)
Pressure Systems
Pump Stations

Table 1 lists the number of data points for each category (project type/project classification) for each agency. As the table shows, there are a number of cells that do not have many collected data points. Tables 2-4 show the average and standard error of % design cost, % construction management cost, and % project delivery cost for each category for each agency. The standard error measures the variability of the mean value. The tables reveal that in a number of cases the averages for the particular project classifications within a category can vary significantly. For example, in Table 2 the % design cost for the street projects in Agency A vary from an average of 12.54 for renovation/resurfacing to an average of 76.04 for bridges (retrofit/seismic). There are many other examples in the tables that illustrate these differences within a category.

This comparison of the respective averages shows the need to potentially account for the different project classifications within a project type separately within a regression model predicting the % design cost, % construction management cost, and % project delivery cost. To further study the appropriate aggregation level, two different regression models were developed. In one type of model, all the data points within a project type category for a particular agency were combined into one regression model without accounting for the different project classifications. This type of model is referred to as the aggregate model. The other type of developed regression model accounts for the different project classifications within the project type category. The second model is referred to as the disaggregate model.

The benefit of the aggregate model is that it allows the combining of data points from the different projects to increase the data set in developing the regression model. However, if there are statistical differences in the averages between the project classifications, this combining (aggregating) of the data points can lead to an aggregate model that is not representative of the real population. In this case, the disaggregate model is the appropriate model to use.

Each type of regression model was run for each project category and agency combination for each dependent variable. The results of the P-values for the two types of regression models for % design cost, % construction management cost and % project delivery cost are shown in Tables 5-10. The (1 – P-value) represents the statistical significance level of the model. Therefore, the smaller the P-value the more statistically significant the developed regression model. P-values of 0.05 typically represent statistical significance of the model, and in some cases regression models that have P-values as high as 0.10 are still used for predicting dependent variables. As Tables 5-10 show, there are many cases where the P-values well exceed this value.

Comparing the P-values of the aggregate model with the disaggregate model shows that in many cases the P-values are significantly reduced when the model accounts for the different project classifications within a project type category. For example, the P-value for the % design cost aggregate model for the street projects in Agency A is 0.773 (in Table 5) whereas it is reduced to 0.003 (in Table 6) for the disaggregate model. This result is consistent with the earlier comparison of the averages for Agency A street projects and clearly shows the need to account for the individual projects and lack of predictive power for the aggregate model.

However, we remark that for some of the project classification and agency combinations the P-value increases slightly when using the disaggregate model. For example, the P-value of the aggregate model for the municipal facility project classification for Agency D is 0.213 which increases to 0.289 for the disaggregate model. This increase can be due to one of two reasons: (1) there is an insufficient number of data points to develop an accurate disaggregate model, or (2) there is not a significant difference between the averages of the various projects within the project type category.

Using an aggregate model when a disaggregate model should have been used leads to far greater errors than making the opposite mistake (that is, using a disaggregate model when an aggregate model should have been used). Since the results clearly show that for some agency and project category combinations an aggregate model is not statistically valid, the *recommendation* is to develop disaggregate regression models. Furthermore, to make the disaggregate models statistically valid, *more* data needs to be collected for some project classifications. Ideally, each project classification and agency combination would have at least ten data points. The results of the regression model for the Los Angels Pipe Systems project illustrate the power of having a lot of data. For this project, the number of collected data points is 21. For this model, the P-value is very small, meaning that the statistical significance of the regression model is high. Finally, it might be worthwhile to study the usefulness of aggregating across agencies to increase the data sets for the regression models.

Regression Models

We study the relationship between the independent variable, sum of construction value and change order, on three different dependent variables: % design cost, % construction management cost, and % project delivery cost. A separate model is developed for each combination of dependent variable (three), project category (three), and agency (six).

To first identify the functional relationship between the dependent and independent variables, plots of the data were generated. Figure 1 shows one such plot. This plot shows the functional relationship for the Agency D gravity system projects. Based on these plots, a negative exponential functional relationship was used. That is,

$$Y_{i,k} = \alpha_0 \exp(\alpha_1 X_{i,k}) \qquad (1)$$

where,

$Y_{i,k}$: dependent variable such as % design cost for project type i for agency k

$X_{i,k}$: independent variable (construction value + change order) for project type i for agency k

α_0, α_1 : model parameters

For scaling purposes, the actual $X_{i,k}$ were divided by 1,000,000. In order to develop linear regression models, the following transformation is used.

$$\ln(Y_{i,k}) = \beta_0 + \beta_1 X_{i,k} \qquad (2)$$

where,

$\beta_0 = \ln(\alpha_0)$

$\beta_1 = \alpha_1$

The above Equation (2) is the regression model used for the aggregate case. The disaggregate model is summarized by Equation (3).

$$\ln(Y_{i,k}) = \beta_0 + \beta_1 X_{i,k} + \Sigma \gamma_j I_{i,j,} \qquad (3)$$

where,

$I_{i,j,k}$: indicator variable which equals one if data for project type i for agency k is of project classification j

γ_j : model parameters

We note that if there are N project types in category i, then N-1 indicator variables are used in Equation (3).

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities						
Libraries	0	6	1	4	2	1
Police/Fire Station	0	7	1	2	6	3
Community Bldg/Rec. Center	0	3	2	3	4	2
Streets						
Widening/New/ Grade Separation	2	4	8	3	4	0
Bridges/Retrofit /Seismic	0	6	0	7	4	2
Renovation/Re surfacing	7	0	9	5	7	0
Bike/Pedestrian /Curb Ramps	6	0	7	7	4	0
Signals	4	0	5	10	7	6
Pipe Systems						
Gravity System (Storm, Sewers)	0	21	0	15	7	4
Pressure Systems	0	0	0	7	6	0
Pump Stations	0	0	0	2	6	0

Table 1. Project Distribution Matrix – Actual

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities						
Libraries		21.89[1], 1.53[2]		19.70, 4.92	24.63, 0.13	
Police/Fire Station		16.53, 1.67		46.43, 39.80	21.13, 8.80	16.64, 6.92
Community Bldg/Rec. Center		20.66, 3.85	15.92, 1.92	28.17, 4.20	26.99, 16.40	34.51, 4.19
Streets						
Widening/New/ Grade Separation	22.95, 7.77	21.43, 4.86	13.16, 3.40	27.09, 5.18	19.53, 5.76	
Bridges/Retrofit /Seismic		22.79, 5.35		76.04, 20.2	17.66, 2.35	31.10, 8.80
Renovation/Resurfacing	16.12, 6.46		8.01, 1.38	12.54, 5.09	11.97, 1.50	
Bike/Pedestrian /Curb Ramps	9.85, 3.46		26.11, 12.00	50.32, 13.9	15.14, 0.97	
Signals	6.47, 0.93		24.32, 4.52	20.31, 2.71	11.55, 1.77	22.14, 12.50
Pipe Systems						
Gravity System (Storm, Sewers)		22.14, 4.37		39.41, 7.69	8.34, 0.84	22.61, 13.10
Pressure Systems				18.22, 2.57	9.23, 2.32	
Pump Stations				22.06, 7.93	15.62, 1.86	

Table 2. Average and Standard Error of % Design Cost

[1]Average
[2]Standard Error

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities						
Libraries		10.26[1], 3.57[2]		14.31, 4.19	20.31, 0.49	
Police/Fire Station		5.87, 0.87		11.79, 3.61	14.10, 1.29	6.13, 2.07
Community Bldg/Rec. Center		7.69, 1.00	20.59, 4.57	10.15, 2.33	15.92, 1.64	8.08, 1.87
Streets						
Widening/New/ Grade Separation	23.88, 20.36	4.78, 2.66	8.51, 1.28	12.80, 2.71	18.52, 6.16	
Bridges/Retrofit /Seismic		9.49, 2.45		21.60, 4.89	10.90, 1.30	21.24, 2.98
Renovation/Re surfacing	17.26, 1.25		6.82, 1.09	31.15, 5.30	16.52, 1.26	
Bike/Pedestrian /Curb Ramps	20.08, 3.33		11.89, 3.36	42.21, 9.88	15.17, 0.99	
Signals	13.30, 2.68		7.78, 2.46	33.35, 3.46	15.74, 0.60	26.04, 6.51
Pipe Systems						
Gravity System (Storm, Sewers)		11.17, 1.35		19.38, 4.13	10.10, 1.52	22.81, 7.23
Pressure Systems				14.64, 2.34	11.75, 3.35	
Pump Stations				15.61, 4.77	12.89, 2.05	

Table 3. Average and Standard Error of % Construction Management Cost

[1]Average
[2]Standard Error

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities						
Libraries		32.15[1],4.39[2]		34.01, 6.63	44.94, 0.40	
Police/Fire Station		22.40, 2.77		58.22, 36.19	35.23, 3.98	22.77, 8.76
Community Bldg/Rec. Center		28.34, 3.07	22.27, 4.89	38.32, 6.09	42.90, 3.82	42.60, 6.06
Streets						
Widening/New/ Grade Separation	46.83, 12.59	26.20, 6.49	21.68, 3.67	39.89, 3.68	38.06, 11.48	
Bridges/Retrofit /Seismic		32.28, 7.35		97.64, 20.92	28.56, 2.33	52.35, 11.78
Renovation/Re surfacing	33.38, 7.56		14.83, 2.28	43.69, 5.48	28.48, 2.50	
Bike/Pedestrian /Curb Ramps	29.94, 4.29		38.00, 14.99	92.52, 19.52	30.31, 1.62	
Signals	19.77, 3.06		32.09, 5.16	53.66, 4.51	27.29, 1.77	48.18, 16.08
Pipe Systems						
Gravity System (Storm, Sewers)		33.31, 5.50		58.78, 9.26	18.44, 2.09	45.42, 16.24
Pressure Systems				32.86, 3.49	20.98, 3.61	
Pump Stations				37.67, 12.69	28.51, 3.98	

Table 4. Average and Standard Error of % Project Delivery Cost

[1]Average
[2]Standard Error

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities	ND	.325	.522	.611	.005	.626
Streets	.211	.213	.355	.773	.425	.413
Pipe Systems	ND	.000*	ND	.013	.024	.940*

Table 5. P-values for Aggregate Model for Design

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities	ND	.263	OA	.775	.070	OA
Streets	.127	.289	.451	.003	.235	OA
Pipe Systems	ND	.000*	OA	.008	.055	.940*

Table 6. P-values for Disaggregate Model for Design

* The Aggregate and Disaggregate model are equivalent since there is only one type of reported facility in the data

ND - No reported data

OA - Only aggregate model was run due to too few data

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities	ND	.654	.075	.094	.010	.988
Streets	.709	.642	.945	.050	.044	.679
Pipe Systems	ND	.013*	ND	.377	.723	.027*

Table 7. P-values for Aggregate Model for Construction Management

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities	ND	.815	OA	.258	.025	OA
Streets	.006	.223	.585	.052	.217	OA
Pipe Systems	ND	.013*	OA	.539	.369	.027*

Table 8. P-values for Disaggregate Model for Construction Management

* The Aggregate and Disaggregate model are equivalent since there is only one type of reported facility in the data

ND - No reported data

OA - Only aggregate model was run due to too few data

Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities	ND	.132	.345	.174	.001	.728
Streets	.074	.301	.406	.123	.909	.928
Pipe Systems	ND	.001*	ND	.001	.257	.103*

Table 9. P-values for Aggregate Model for Project Delivery

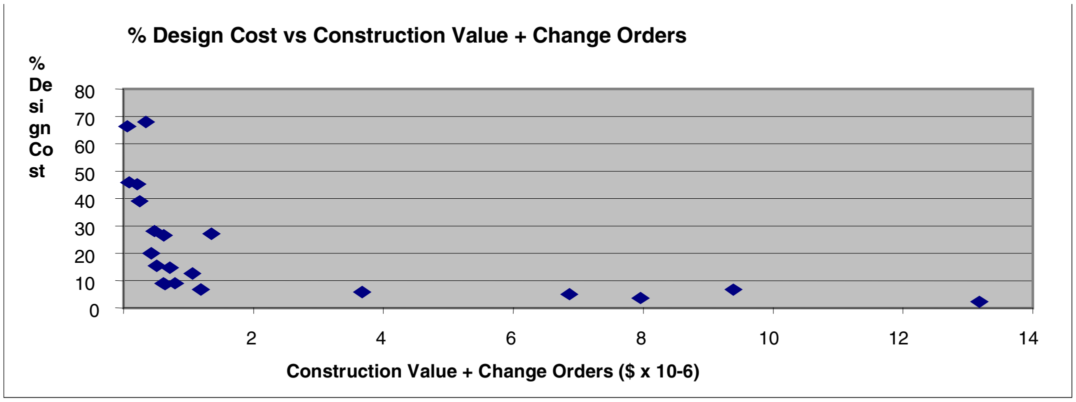
Project Type	Agency E	Agency D	Agency B	Agency A	Agency C	Agency F
Municipal Facilities	ND	.213	OA	.475	.017	OA
Streets	.198	.196	.292	.143	.799	OA
Pipe Systems	ND	.001*	OA	.000	.180	.103*

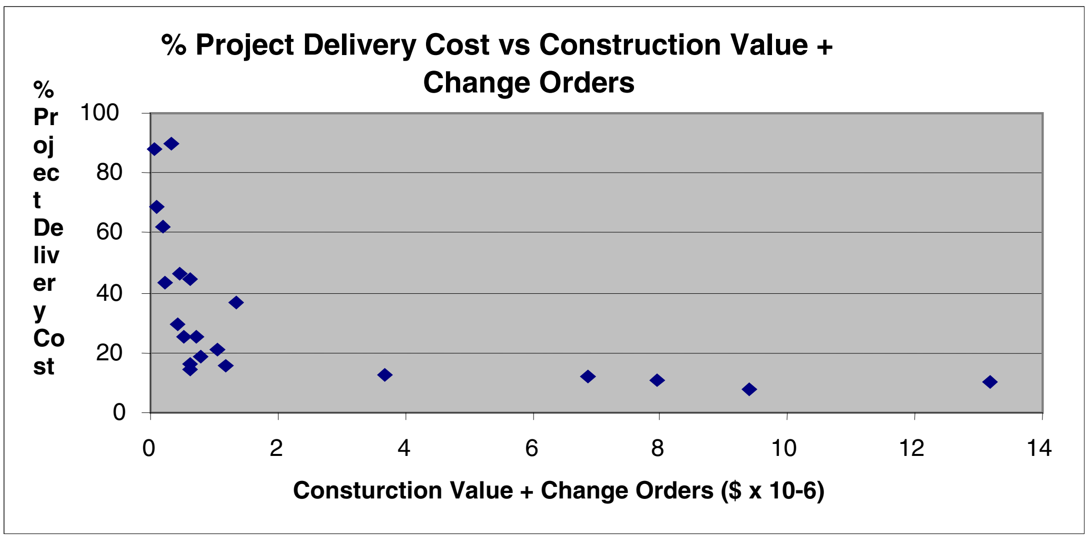
Table 10. P-values for Disaggregate Model for Project Delivery

* The Aggregate and Disaggregate model are equivalent since there is only one type of reported facility in the data

ND - No reported data

OA - Only aggregate model was run due to too few data





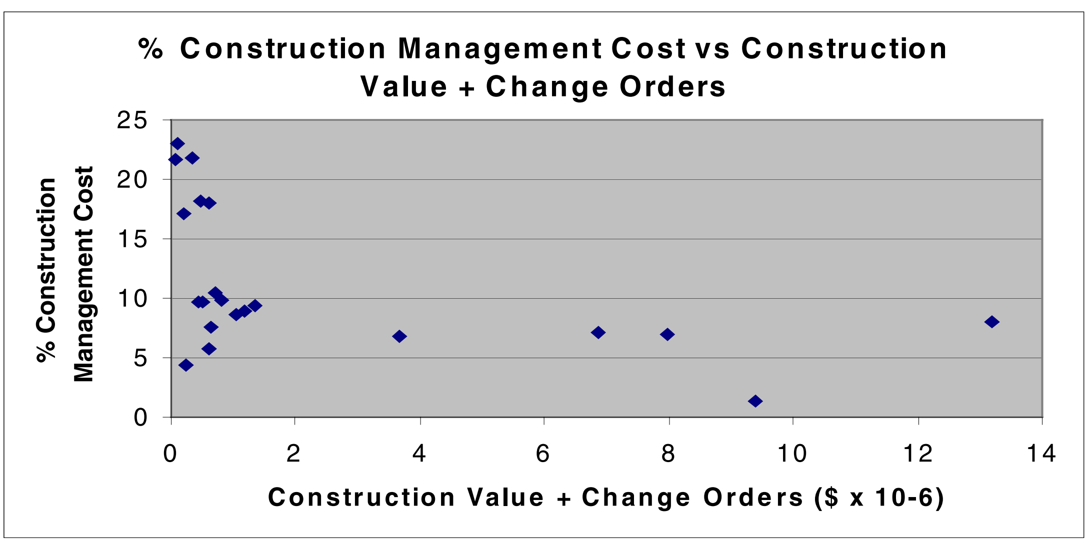


Figure 1. Plot of Data for Agency D Gravity System Projects

B-II. Outliers Elimination

Summary

The purpose of this section is to introduce an approach to improve the fitness of a regression curve to the collected data (i.e. increasing the value of R^2). Statistical outliers elimination is the technique that is used here and explained in this section. It is noteworthy that elimination of outliers would require setting aside data points that are too far from the regression curve. Therefore, application of this technique is not recommended at this phase of the study and we may get a reverse result in some cases (decreased R^2), due to very limited number of data. This approach is presented here as a guideline to be applied at future stages of this study, when enough data is collected.

Definition of Outliers

From statistical point of view, data points that are too far from the average of a data set are called "Outliers". In the following example of 10 data points, it is obvious that data point #3 is an outlier since it is too far from the average (0.073), compared to the other data points. This could be a result of data collection error or merely bad data selection (non-representative). The decision of "how far" from the average is too far and which data points should be set aside is made by using the following statistical technique.

Record #	1	2	**3**	4	5	6	7	8	9	10	Average	Standard Deviation
Data	0.010	0.030	**0.340**	0.070	0.010	0.020	0.030	0.080	0.050	0.090	**0.073**	**0.093**

Statistical Elimination of Outliers

The statistical technique to identify outliers looks at the value of each data point and compares it with the range: $[Q_1 - 1.5(Q_3 – Q_1)\ ,\ Q_3 + 1.5(Q_3 – Q_1)]$

Where: Q_i = i^{th} Quartile of the data set.

For the 10 data points in the above example, the range would be calculated as [-0.06 , 0.16] which shows that record #3 is an outlier, and the only outlier.

It is noteworthy that after setting aside all outliers, the values of Q_i's change and the process need to be repeated to assure that there are no more outliers. In the above example, after removing record #3, the range changes to [-0.06 , 0.145] which covers all remaining data points. In this case, no further elimination is necessary.

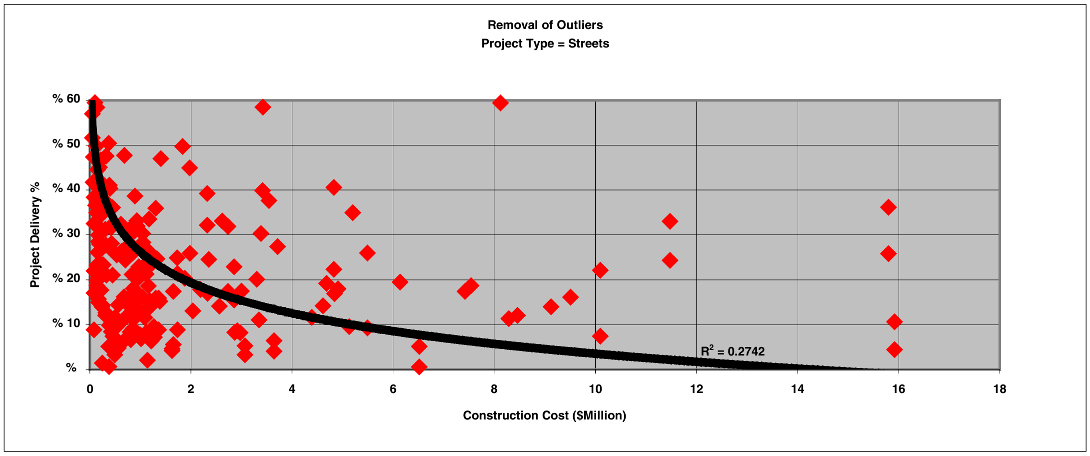
Application to Regression Curves Optimization

In a linear regression (Y=a + b.X), outliers are defined by data points whose residuals ($\hat{Y}_i – Y_i$; Y_i is the regression estimate for i^{th} X and $\hat{Y}_i$ is the i^{th} observation of Y) are too far from the average of all residuals. Therefore, we can apply the above technique to the residuals of a regression curve to identify and set aside outliers.

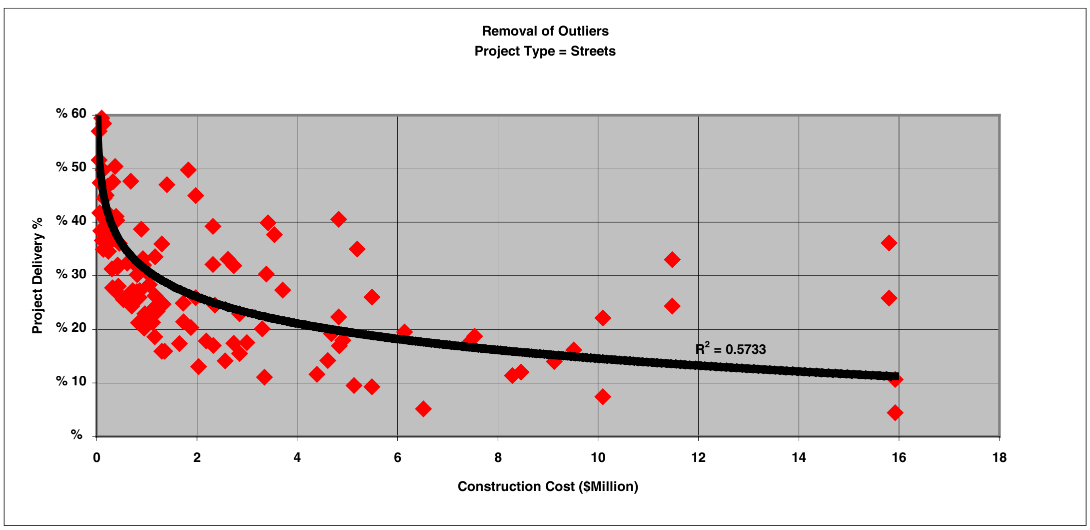
Application to This Study

In this Benchmarking study it was concluded that a logarithmic regression would be most appropriate and all performance graphs are developed using this option (Appendix D-III, pages D-31 – D-74). However, in order to formulate the above outliers' elimination technique, linear regression is the most convenient one. Specifically, Microsoft Excel was used for this purpose which has a regression analysis package built in. The solution to the above problem is simply transforming X values to Log (X) values. In other words, we analyze the linear regression between Log (X) and Y.

Figure 1 shows the results of applying the outliers elimination technique to the Project Delivery % curve for "Streets". In figure 1.a all the outliers are included and, as a result the global R^2 value is very low (0.274). After removing the outliers, the R^2 value significantly increases (0.573), at the expense of loosing about 27% of data points. Also note the change in the trend of the regression curve that appears to be more realistic (encompassing more data points) after elimination of outliers.



a – Original regression curve, including outliers



b – Regression curve, after elimination of outliers

Figure 1 – Sample Outliers Elimination for Performance Curves

B-III. Selection and Confidence Level of Upper-Bound Regression[2]

[2] Reference: Crow, Edwin L.; Davis, Frances A.; Maxfield, Margaret W. Research Department, U.S. Naval Ordinance test Station. Statistics Manual. Dover Publications, Inc. New York

Summary:

The purpose of this section is to discuss and define the statistical model that forms the basis for the band above the performance regression curve. The band was developed to indicate the range of a confidence interval in the curve. On the lower side, it is unbounded and the upper-boundary is a curve that translates to a 70% confidence level for normal distribution and 81% confidence level for lognormal distribution.

Discussion

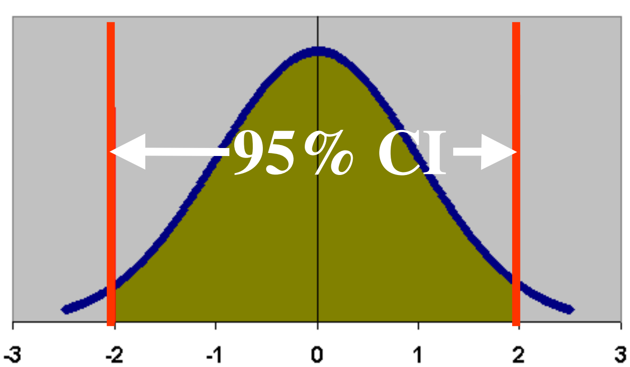
As a general rule, it is a reasonable statistical assumption that collected data has a normal distribution. However, in the case of this study the project data collected is skewed to the left, somewhere between normal and lognormal distribution. It follows that using $(-\infty, \mu+0.5\sigma]$ which translates to a 70% confidence level for normal distribution, could result in as high as 81% confidence level (lognormal distribution) in some cases. In other words, *assuming that the regression model is statistically acceptable, we are between 70% (normal distribution) and 81% (lognormal distribution) confident that delivery costs of a new construction project will fall bellow the upper-limit curve of the corresponding performance graph.*

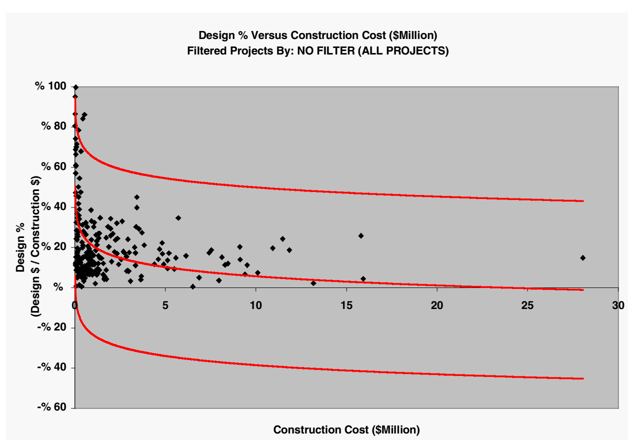
Definition of Confidence Interval

Confidence interval is the interval within which a mathematical statement is correct, with a predefined certainty. For example, a 95% Confidence interval for value $\overline{x}$ (sample average) defines a range around $\overline{x}$ whose value is the same as the parent population average (μ), with 95% certainty.

If the statistical distribution of data is known, Confidence Interval can be estimated as a range around average (μ), defined by standard deviation of the data (σ). For example, as shown in Figure 1, for a normal distribution, $\mu \pm 1.96\sigma$ provides 95% confidence interval. As a rule of thumb, $\mu \pm 2\sigma$ is used to estimate the 95% Confidence Interval for randomly collected data from a population that is expected to have a normal distribution.

Figure 1 – Confidence Interval for Normally Distributed Data





Application to Development of Upper-Bound Regression Curve

For the purpose of this study, $[\mu-2\sigma , \mu+2\sigma]$ provides a too wide range and it is not practical. Through experiment and evaluation of various ranges, it was observed that $(-\infty, \mu+0.5\sigma]$ provides a more practical and useful tool. The rationale for using $(-\infty, \mu+0.5\sigma]$ follows:

1. In this study we are not interested in the lower-bound limit. We only need to identify the maximum value that is used in the industry, not the minimum. Therefore the Confidence Interval is defined by $(-\infty , \mu + \alpha . \sigma]$. For a given distribution and a given Confidence Limit (CL), α can be estimated by looking for CI = (2.CL - 100)% value in the table of the corresponding distribution[3]. For the normal distribution, for example, to gain a 70% Confidence Level (CL), we need to look up the value of α for CI=(2x70-100)% = 40% which is equal to 0.5. Therefore <u>*$(-\infty, \mu+0.5\sigma]$ would provide 70% Confidence level, if the data had a normal distribution*</u>.

2. The above formulations are based on the assumption that the collected data are distributed normally. The project data was investigated and we observed that, in reality, actual distribution of the data is not normal. As a matter of fact, the histogram of the projects data was developed for various variables and categorizations and it appeared to be somewhere between normal and lognormal distribution. For example, Figure 2 (page B-23) shows the actual histogram for all Design% values compared to normal and lognormal distributions. The left-skewed nature of this curve can be explained by the fact that, in the sample, there are more number of projects with small design costs than projects with large design costs. This feature can be attributed to the parent population as well; in general <u>*most of the CIP projects have small design costs and there are just a few projects with large design costs*</u>. Therefore, we can safely use a lognormal distribution to model our data. Lognormal distribution provides a higher Confidence Level compared to normal distribution, as explained below.

In the specific example shown in Figure 2, we can see that the proposed interval of $(-\infty, \mu+0.5\sigma]$ results in a Confidence Level of 70% for normal distribution, 81% for lognormal distribution, and 85% for the real data. In this special case, the real data results in a higher Confidence Level than lognormal distribution (81%). However, data investigations showed that in some cases it falls less, but not less than normal distribution (70%). Therefore it can be concluded that, <u>*assuming appropriateness of the regression model, we are between 70% and 81% confident that design cast of a CIP Project falls below the upper-bound regression curve that is shown in figure 3*</u>. This is true for other performance benchmarks, too (construction management, change orders, and duration). They all have a left-skewed distribution, like the above example.

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[3] Note that CI is the confidence Interval, if there was a lower-bond too $[\mu - \alpha . \sigma , \mu + \alpha . \sigma]$. In the database program we use CI as the input variable, since we generate the lower-bond curve as well as the upper-bond, in case of applicability. In this specific study, all lower-bond curves are deleted from the performance graphs.

Figure 3 shows the [μ , $\mu \pm 0.5\sigma$] regression band for Design% curve of all projects data. It can be seen that most of the data points are included in this band and this band (which as an actual Confidence Interval of 85%), is a good predictor of Design Cost as a percentage of Construction Cost (Assuming statistical validity of global data aggregation).

It is noteworthy that in one of the project meetings it was proposed to use the average distance of the complex projects regression curve from the global regression curve as the upper-bound. Figure 4 shows that this proposal almost coincides with $\mu + 0.5\sigma$ for the above example.

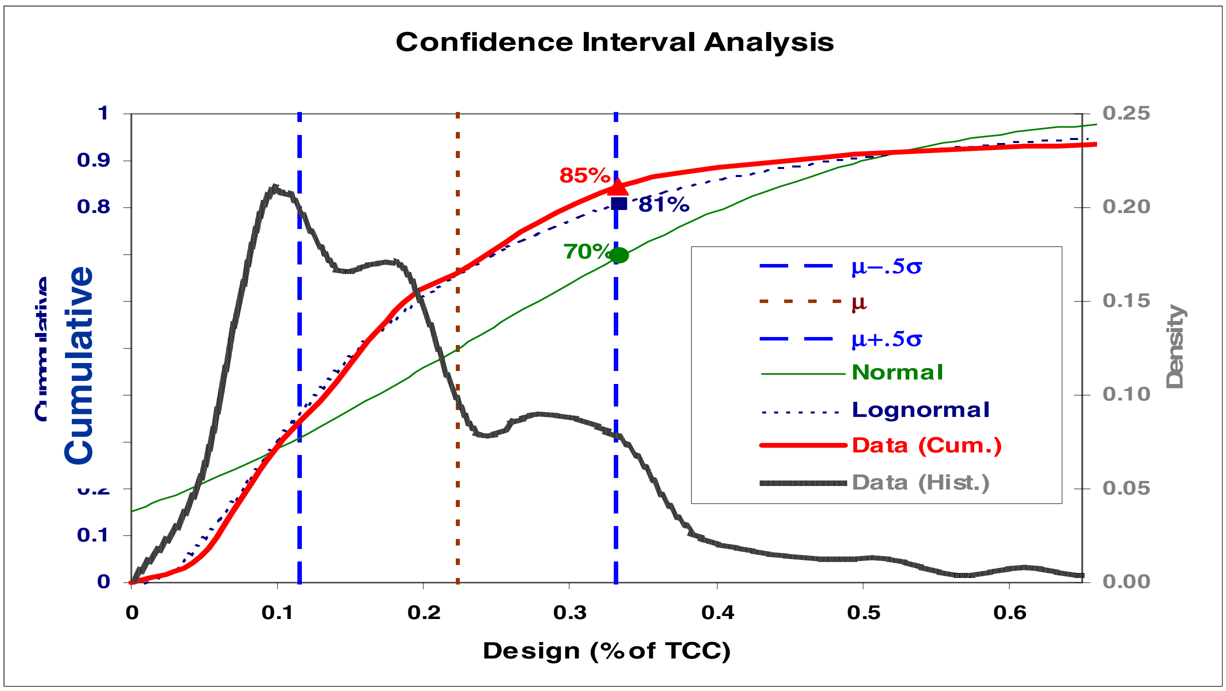


Figure 2 - Actual Confidence Interval for $\mu \pm 0.5\sigma$ - All Design% Data

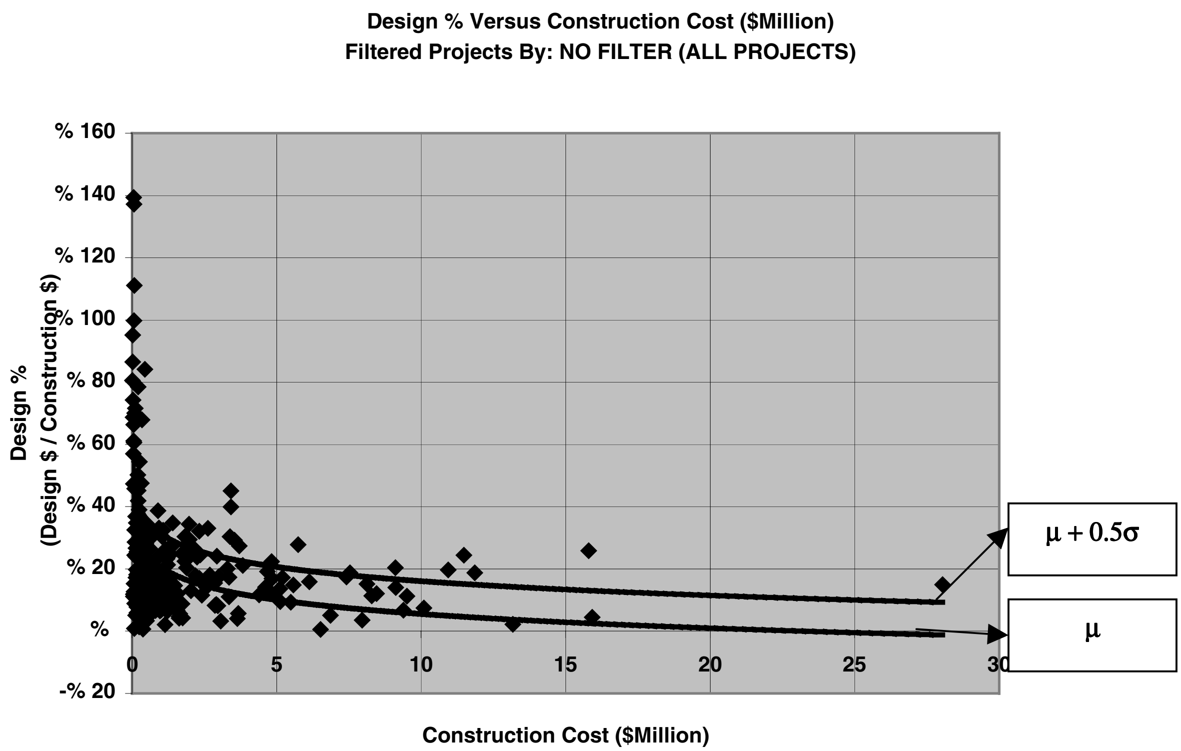


Figure 3 – Regression Band for $\mu \pm 0.5\sigma$ - All Design% Data

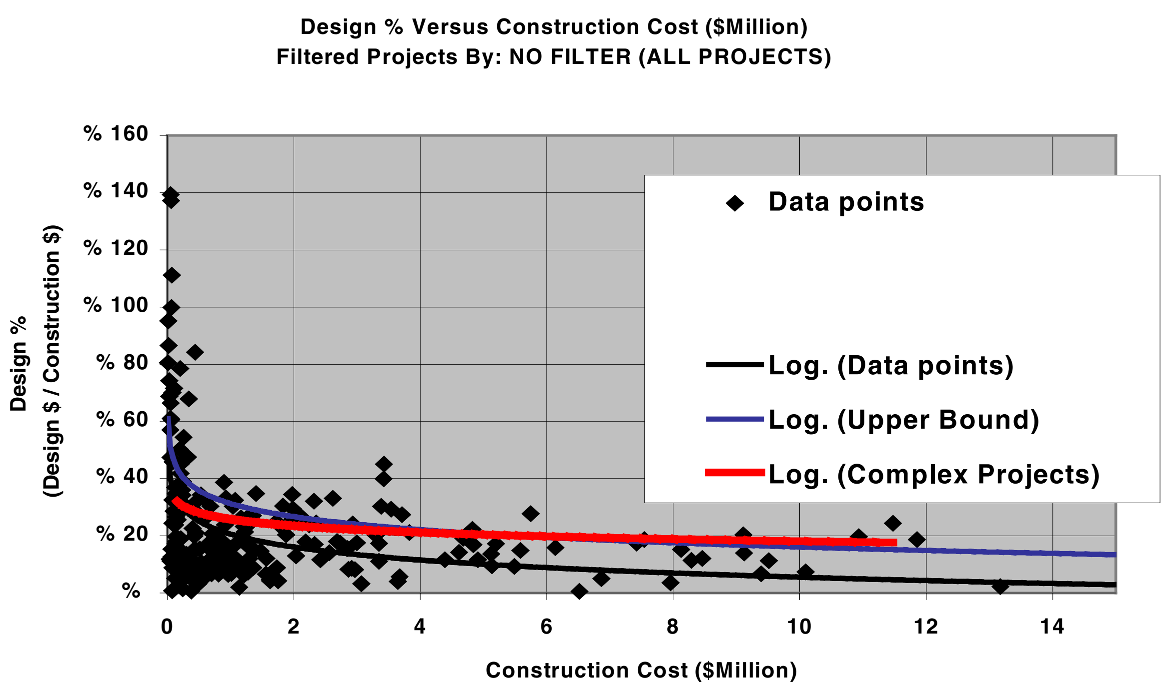


Figure 4 – Comparison with Complex Projects Regression curve

B-IV. Application of Projects Indexing

Summary

Project Indexes were originally intended to provide another level of projects categorization and assist agencies in distinguishing among projects in reference to their complexity (simple, normal, or complex), and in reference to their nature (New or Rehabilitation). However, due to very limited number of data points, application of complexity index is not practical, unless more date points are collected on various categories. The statistical analysis in Appendix C suggests that we need at least 10 data points per each classification for each agency. This number, in fact, needs to be multiplied by 3 in order for project indexing to be applicable.

In this section of the report we redevelop Project Delivery % curves regression curves (as an example) by categorizing data points by their “Complexity Index” and by their “New/Rehab” index. These curves are reviewed and discussed. We identify areas of improvement and additional data collection.

Process

In order for Project Indexing study, a level of categorization was added to the project that corresponds to Complexity Index and New versus Rehab Index. As an example, Project Delivery % results were reviewed for all project types/Classifications and the results are summarized here

Outcomes

Complexity Index:

- *Global (All Data):* Small "Simple" Projects do not make sense. Relation between "Complex" and "Normal" projects is good, intuitively, but not conclusive.
- *Municipal Facilities: Only* small “Complex” projects (< $2.5M), and large “Simple” projects (> $6M) make sense.
- *Pipe Systems:* Mostly “Normal” projects. There are no “Simple” projects and only two “Complex” projects. Cannot make any conclusion.
- *Streets:* There are no “Simple” projects. Good trend for “Normal” and “Complex” Projects in the beginning. But they get close to each other as the project size increases, instead of going away from each other.

New/Rehab:

- *Global (All Data):* The two curves are very close, i.e. this index is not important, in general
- *Municipal Facilities:* The two curves are almost overlapping. The index is unimportant.
- *Pipe Systems:* The two curves intersect. Cannot make any conclusion. Probably we have bad data.
- *Streets:* The two curves are very close, i.e. this index is not important

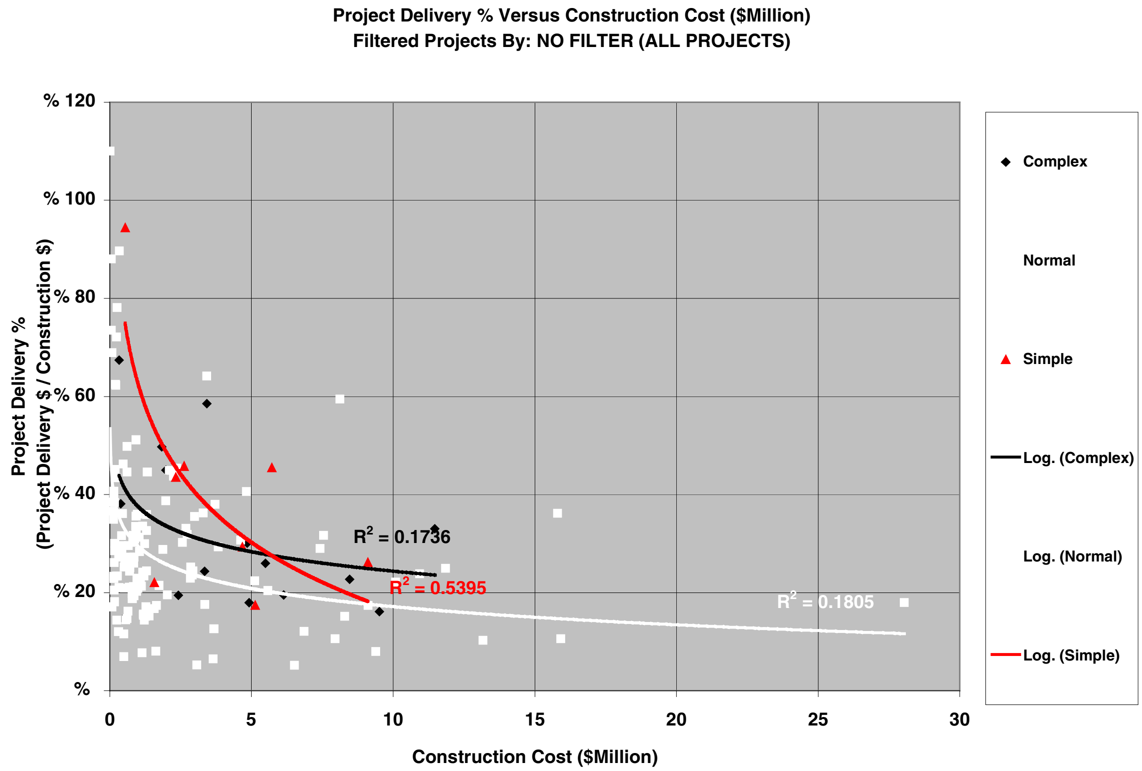
Most of the large projects are "New" projects and "Normal" projects. This results in misrepresentation of the Indices.

Conclusion and Recommendation

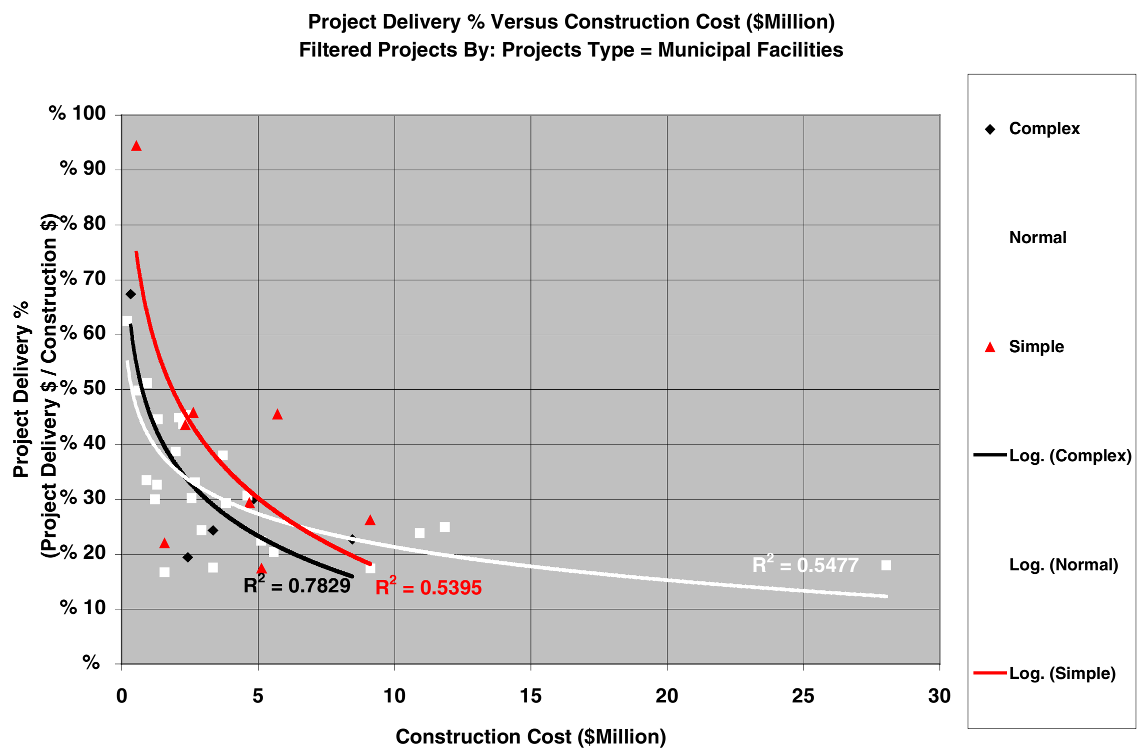
Revisit Projects Data:

- Some "Simple" projects may not be really simple.
- More complex and/or simple projects are needed. Especially in "Pipe Systems" and "Streets" Categories.
- Revisit New/Rehab indices for "Pipe Systems". We may need to collect more projects.
- It may be concluded that New/Rehab index is not important, depending on the outcome of new data for "Pipe Systems".
- Indices are not distributed appropriately among various project sizes.

It is recommended to collect more "complex" and "Simple" Projects, more smaller size projects, and more "Pipe Systems" Projects with diverse New/Rehab indices.

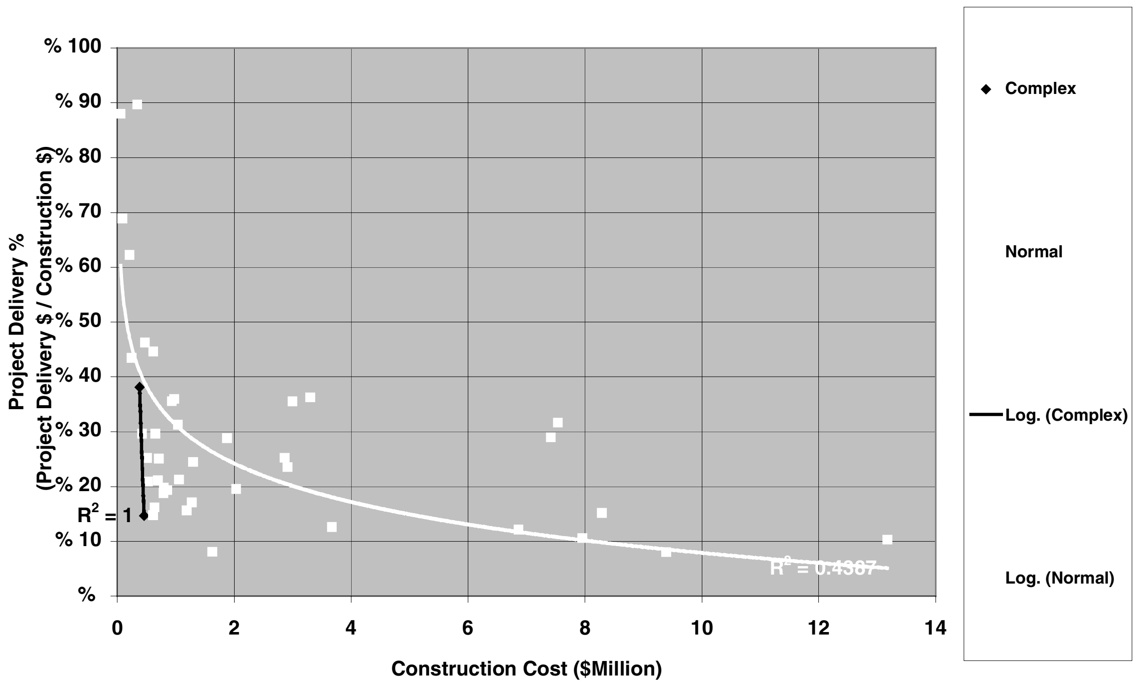


Project Delivery % Versus Construction Cost ($Million)
Filtered Projects By: NO FILTER (ALL PROJECTS)
% 120
% 100
% 80
% 60
% 40
% 20
%
0
5
10
15
20
25
30
Project Delivery %
(Project Delivery $ / Construction $)
Construction Cost ($Million)
R^2 = 0.1736
R^2 = 0.5395
R^2 = 0.1805
Complex
Normal
Simple
Log. (Complex)
Log. (Normal)
Log. (Simple)

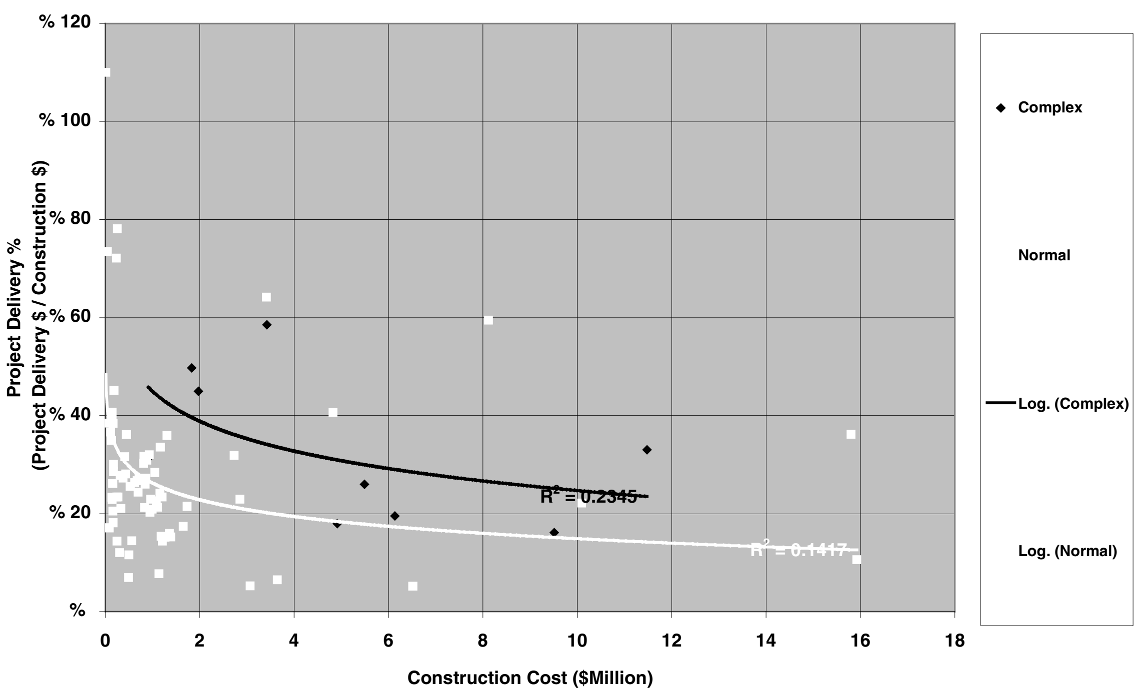


Project Delivery % Versus Construction Cost ($Million)
Filtered Projects By: Projects Type = Municipal Facilities
% 100
% 90
% 80
% 70
% 60
% 50
% 40
% 30
% 20
% 10
%
0
5
10
15
20
25
30
Project Delivery %
(Project Delivery $ / Construction $)
Construction Cost ($Million)
R^2 = 0.7829
R^2 = 0.5395
R^2 = 0.5477
Complex
Normal
Simple
Log. (Complex)
Log. (Normal)
Log. (Simple)

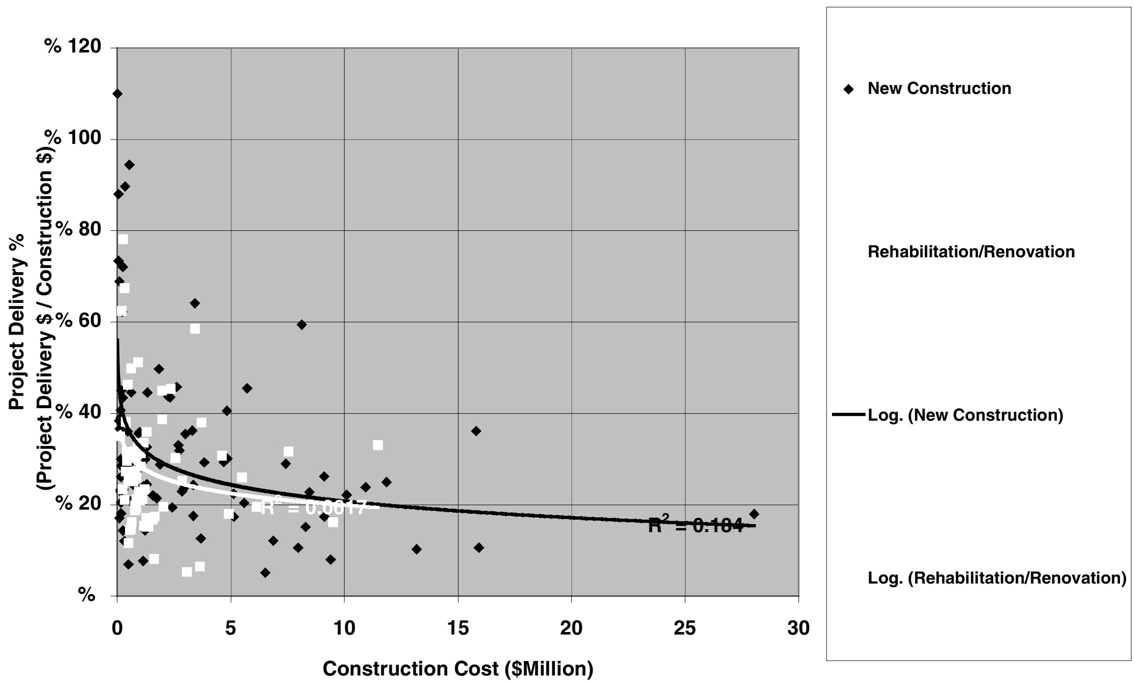
Project Delivery % Versus Construction Cost ($Million)
Filtered Projects By: Projects Type = Pipes



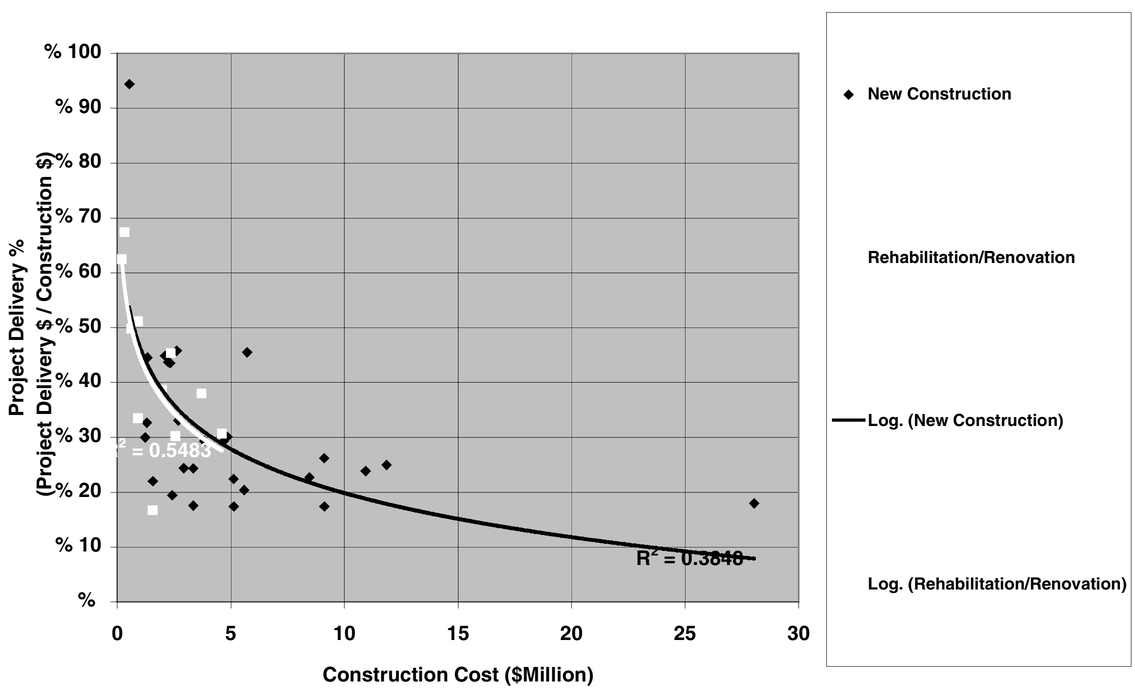
Project Delivery % Versus Construction Cost ($Million)
Filtered Projects By: Projects Type = Streets

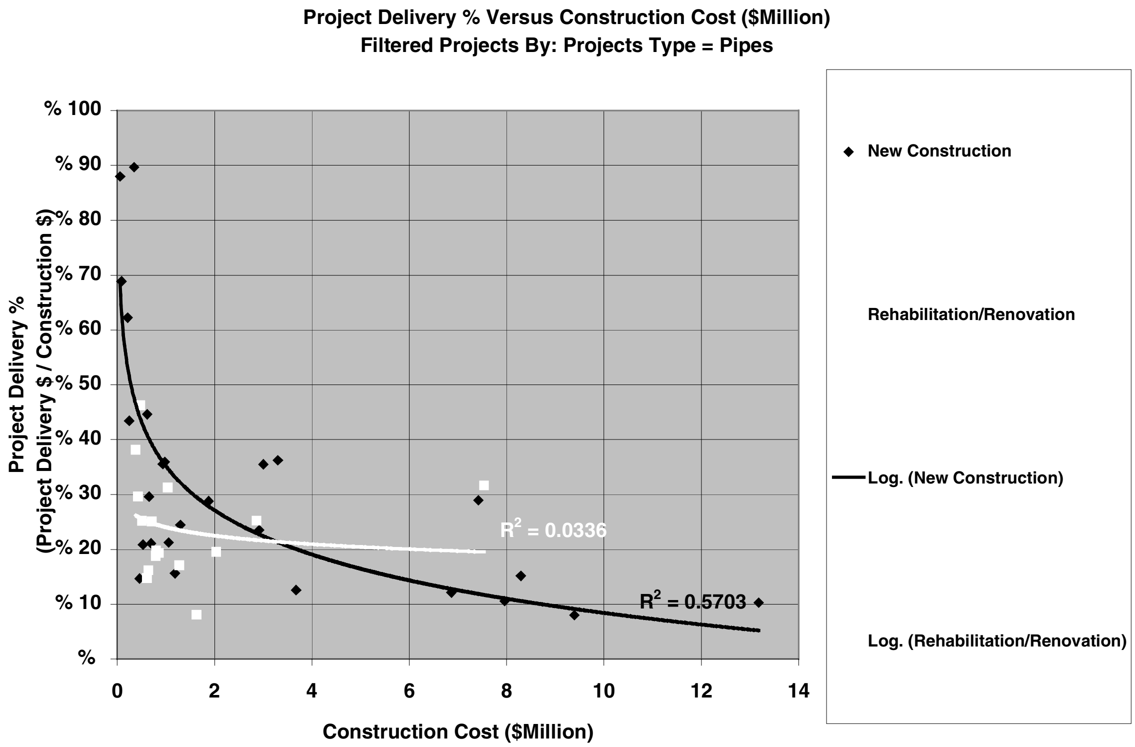


Project Delivery % Versus Construction Cost ($Million)
Filtered Projects By: NO FILTER (ALL PROJECTS)



Project Delivery % Versus Construction Cost ($Million)
Filtered Projects By: Projects Type = Municipal Facilities




Project Delivery % Versus Construction Cost ($Million)
Filtered Projects By: Projects Type = Pipes
% 100
% 90
% 80
% 70
% 60
% 50
% 40
% 30
% 20
% 10
%
Project Delivery %
(Project Delivery $ / Construction $)
0
2
4
6
8
10
12
14
Construction Cost ($Million)
$R^2 = 0.0336$
$R^2 = 0.5703$
New Construction
Rehabilitation/Renovation
Log. (New Construction)
Log. (Rehabilitation/Renovation)

Appendix C
Process Questionnaire

Process Definition / Question		Agency(2)							Comments
(Scale: 0=No/Never, 5=Yes/Always(1), OR AS DEFINED)		LA	LB	SC	SD	SF	SJ	Avg.	
1. Planning Process									
a.	Capital projects are well defined with respect to scope and budget at the end of the planning phase	5	1	3	2	4	4	3.2	
b.	Feasibility studies are completed on projects prior to defining budget and scope	1	1	3	1	2	2	1.7	SC: For transportation projects
c.	Projects require an appropriation before any planning or design is started	2	0	0	4	5	4	2.5	SC: Planning starts, not design
d.	There is a Board/Council project prioritization system	0	0	5	0	0	1	1.0	SC: Only for transportation projects
e.	Projects listed in the CIP are resource loaded for design and construction	4	0	2	0	0	4	1.7	
f.	There is a Master Schedule attached to the CIP that identifies start and finish dates for projects?	5	0	5	2	0	5	2.8	
g.	There is an annual report to the City Council required	5	0	0	0	1	5	1.8	
h.	CIP project implementation planning is based on available Project Management Staff	3	0	1	0	3	1	1.3	
i.	Projects shown on a Geographical Information System	5	2	5	1	2	4	3.2	
j.	There is an objective system for qualifying projects for the CIP prior to them becoming part of the CIP	2	2	1	2	2	5	2.3	
k.	Public Works/Engineering is required to sign off on scope, budget, and schedule before a project gets entered into the CIP	4	2	5	0	2	2	2.5	SC: Only for transportation projects
l.	Project Management staffing is based on CIP projects to be implemented	5	0	1	0	4	4	2.3	
m.	There is public involvement in the CIP development process (outside of CEQA)	1	2	3	3	0	3	2.0	
n.	Who signs off on a project to get it into the CIP prior to City Council approval?								LA: Mayor's Budget; LB: CIP committee; SC: Budget and Sponsorship Dept.; SD: DCM; SF: Director of Public Works; SJ: Budget Director

(1) Unless identified otherwise, use 2 for up to 40%, 3 for up to 60%, 4 for up to 80%, and 5 for more the 80% of projects

(2) Agencies Abbreviations Listed in Alphabetical Order:

LA= City of Los Angeles, DPW/BOE

LB= City of Long Beach, DPW

SC= City of Sacramento, DPW

SD= City of San Diego, ECP

SF = City of San Francisco, DPW/BOE/BOA/BCM

SJ = City of San Jose, Department of Public Works

Darkened Scale: Scale not applicable. Only comments

Appendix C
Process Questionnaire

Process Definition / Question (Scale: 0=No/Never, 5=Yes/Always[1], OR AS DEFINED)		Agency[2] LA	LB	SC	SD	SF	SJ	Avg.	Comments
2. Design									
a.	Designers are given a specific budget prior to design start	4	4	5	5	4	5	4.5	
b.	Designers are given a clear, precise scope prior to design start	4	1	4	2	4	4	3.2	
c.	Designers are given a milestones schedule by which to deliver documents prior to design start	5	1	2	2	3	5	3.0	
d.	Designers are required to provide a work plan or design schedule prior to design start	2	0	5	4	4	5	3.3	
e.	Design fees/budgets are based on (1) a percentage of construction cost; (2) lump sum; or, (3) cost plus a fee								LA: (1); LB: (1); SC: For Budget (1), For Fee (3); SD:(2); SJ:(2)
f.	Design requirements for reliability, maintenance, and operation are defined prior to design start	4	1	1	3	3	3	2.5	
g.	Designs are done on 2D CAD systems	5	4	5	5	5	4	4.7	
h.	Designs are done on 3D CAD systems	1	2	1	3	1	0	1.3	
i.	Site adaptations of successful designs are used whenever possible (e.g. fire stations, gymnasiums, etc.)	4	2	3	0	3	2	2.3	
j.	Surveyors are in-house	5	4	4	5	5	4	4.5	
3. Quality Assurance / Quality Control									
I. Standard Project Execution Procedures									
a.	A standardized Project Delivery Manual is developed and is being used	5	0	1	1	2	4	2.2	
b.	Flowcharts and/or checklists are used to standardize documents management	5	1	2	1	2	5	2.7	
c.	Roles and responsibilities of team members are clearly defined in a Project Management Plan	5	0	4	1	3	4	2.8	
d.	Agency uses standard forms for RFI's, Change Orders, Pay Applications, Field Clarifications, Minutes of Meetings, etc.	5	5	4	4	5	4	4.5	
II. Constructibility Review and Value Engineering									
a.	A Constructibility Review Process is implemented on projects	3	3	2	3	4	2	2.8	
b.	A Value Engineering analysis is performed on projects	3	1	1	1	1	1	1.3	
c.	Constructibility Review is done independent of the designer	5	4	3	4	4	1	3.5	
d.	Value Engineering is done independent of the designer	5	1	0	1	1	1	1.5	
e.	There is a Constructibility Review or Value Engineering Coordinator within the agency who is responsible for management and implementation of the process	0	0	0	0	1	0	0.2	
f.	Cost saving resulting from Constructibility Review and/or Value Engineering are tracked	5	0	0	0	0	1	1.0	

Appendix C
Process Questionnaire

Process Definition / Question (Scale: 0=No/Never, 5=Yes/Always[1], OR AS DEFINED)	Agency[2] LA	LB	SC	SD	SF	SJ	Avg.	Comments
III. QA/QC Procedures								
a. A formal Quality Management System is used	0	0	2	1	3	1	1.4	
b. Post Project Reviews are performed and used for lessons learned	3	0	3	0	3	1	1.7	
c. Inspection is on site full time for projects under construction	5	4	2	3	4	2	3.3	
d. Inspectors are Agency employees	0	4	3	5	5	5	3.7	
e. Laboratory and testing services are in-house	0	0	0	5	5	5	2.5	
f. Inspection consultants/contractors are required to carry Errors & Omissions insurance	5	4	3	5	5	5	4.5	
g. Inspectors are trained and, when required, certified	5	5	5	5	5	5	5	SC: Facilities certifications
h. The Agency's Quality Management approach includes International Organization for Standardization (ISO) certification *Examples: ISO 9000-General Quality Assurance Terms and Overview* *ISO 9001-Engineering and Design* *ISO 9002-Fabricator and Constructor* *ISO 9003-Distribution Centers/Warehouses* *ISO 9004-Quality definitions*		0	0	0	5	0	0.8	
i. Inspectors are separately budgeted	5	1	1	5	5	0	2.8	
j. Inspection personnel are independent from Project Management team	5	4	1	5	5	2	3.7	
4. Construction Management								
I. Change Order Processes								
a. The City Engineer / Public Works Director has authority to approve change orders. (0 for none, 1 for <10^k, 2 for 10^k - 25^k, 3 for 25^k - 50^k, 4 for 50^k - 100^k,5 for >100^k)	4	5	4	5	5	4	4.5	LB: Varies per project (25% of const cost); SF: Although they have the authority, this task has been delegated to the Chief of Construction Management.
b. Change order policies provide that there is a separate contingency account for Errors & Omissions and Changed/Unforeseen conditions	0	0	0	0	0	0	0.0	
c. Change order policies provide that there is a separate contingency account for Owner/User required scope revisions	0	0	0	0	0	0	0.0	
d. A formal standard change order process is in place, which defines all forms and methods necessary to finalize change orders	5	5	5	5	5	5	5.0	
e. Project managers have estimators available to perform comparative estimates on change orders	5	2	2	0	3	2	2.3	
f. A change order contingency is set aside at the start of the project	5	5	5	5	5	5	5.0	
g. What % change order contingency is set aside? ((0 for none, 1 for <5%, 2 for 10%, 3 for 15%, 4 for 20%,5 for 25%)	4	5	2	2	2	2	3.4	SJ: 5%

Appendix C
Process Questionnaire

Process Definition / Question (Scale: 0=No/Never, 5=Yes/Always[1], OR AS DEFINED)	LA	LB	SC	SD	SF	SJ	Avg.	Comments
h. The change order contingency varies with new versus renovation/rehabilitation projects	0	0	5	5	1	5	2.7	
i. All changes are required to go through a formal change justification procedure	5	2	5	5	5	5	4.5	
j. Project areas susceptible to change are identified and risk is evaluated prior to determining the final budget	2	0	2	2	2	2	1.7	
k. Project team members take proactive measures to promptly settle, authorize, and execute change orders	5	4	3	3	3	4	3.7	
l. There is a communication system in place for the efficient exchange of information related to changes between project team members	5	3	5	1	3	4	3.5	
m. Types of changes are being classified	5	1	0	1	5	0	2.0	SJ: &O/Client?/design??
n. Change orders are required to be settled "full and final" at the time they are executed	5	4	5	5	2	4	4.2	
o. Markups for Change Orders for Overhead & Profit are: 0 for 10% and less, 1 for 15%, 2 for 20%, 3 for 25%, 4 for 30%, 5 for more	1	1	0	5	2	5	2.3	SF: 24% - Labor, 15% - Material, 15% - Equipment; SJ: labor @ 33%, other @ 15%, subs additional 5%
II. Dispute Mitigation / Resolution Procedure								
a. A formal Dispute Resolution Procedure is included in all contract agreements	5	0	5	5	0	0	3.0	
b. Dispute Review Boards (DRB) are used	5	0	0	1	1	0	1.2	
c. Dispute Mitigation techniques, such as partnering, are used	5	1	1	3	1	1	2.0	
d. An Arbitration clause is included in the contract documents	5	0	5	5	0	0	2.5	
III. Partnering								
a. A team building process is used for projects	3	1	5	3	1	1	2.3	
b. Regular team building meetings are held throughout the projects life	3	1	4	2	1	1	2.0	
c. Performance of team is checked against team agreed goals on a regular basis	3	1	3	2	1	1	1.8	
IV. CM Procedures								
a. Construction Management team is first involved at what phase of design or construction?								LA: After Contract; LB: final design; SC: After Final Design; SD:75%; SF: Design; SJ: mid-point of design
b. CM fees/budgets are based on a percentage of construction cost or a lump sum								LA: Percentage; LB: percentage; SC: Budget %, fee is cost + fee; SD: LUMP SUM; SF: Lump Sum; SJ: % const cost
c. CM team is required to develop and implement a Construction Management Plan (Communication, Responsibilities, and Goals)	5	3	5	2	2	1	3.0	LB: ; SD: ; SF: For major projects only (> $10Million)

Appendix C
Process Questionnaire

Process Definition / Question (Scale: 0=No/Never, 5=Yes/Always[1], OR AS DEFINED)	Agency[2] LA	LB	SC	SD	SF	SJ	Avg.	Comments
d. Surveyors are in-house	5	4	4	5	5	4	4.5	
5. Project Management								
I. PM Authority, Responsibility, and Accountability								
a. The Agency is responsible for the Bid and Award Process (as opposed to the client doing the bid and award)	5	4	5	5	4	5	4.7	
b. Design PM's signature is sufficient for Contract Documents	0	0	0	0	0	0	0.0	SD: DEPUTIZED SENIOR
c. Construction decisions (Budget, Scheduling, and Justification) are made by the Project Manager	5	3	5	3	3	1	3.3	
d. A project Manager is Assigned to Every Project	5	2	5	5	5	5	4.5	
e. Project Manager has "cradle to grave" involvement	5	2	5	5	4	4	4.2	
f. There is a client representative assigned to every project	2	3	5	3	5	5	3.8	
g. Routine, timely, accurate "Labor expended" reports are available to the Project Manager	5	1	5	4	4	4	3.8	
h. PM has the authority to recruit / terminate Team members	0	0	2	0	3	0	0.8	
i. PM processes Change Orders without upper-level approval	5	0	0	4	4	0	2.2	
II. Training of Project Managers/Engineers								
a. Formal Training is provided for PMs on a regular basis	5	0	1	3	5	2	2.7	
b. Formal Training is provided for Support Staff	5	0	1	2	4	2	2.3	
c. Technical Training is provided for Engineers	5	3	5	2	4	0	3.2	
III. Project Controls System								
a. A standard Project Controls System has been adopted by the Agency and is in use on all projects	5	2	5	2	4	5	3.8	LB: Just begun 1/1/02
b. Computerized and/or web-based project management tools are used	1	2	5	4	4	2	3.0	LB: Just begun 1/1/02
c. Archiving and retrieval of projects information is facilitated by an in-house database	5	2	5	2	3	1	3.0	LB: Just begun 1/1/02
d. Project forms and documents are on-line and are filled out and communicated between team members electronically	2	2	3	1	1	1	1.7	LB: Just begun 1/1/02
6. Consultant Selection and Use								
a. Consultants are required to comply with Agency indemnification and insurance requirements	5	5	5	5	5	5	5.0	

Appendix C
Process Questionnaire

Process Definition / Question		Agency(2)							Comments
(Scale: 0=No/Never, 5=Yes/Always(1), OR AS DEFINED)		LA	LB	SC	SD	SF	SJ	Avg.	
b.	Documents produced by the consultants belong to the Agency	5	5	5	5	5	5	5.0	
c.	A Standard Consultant contract is included in the RFQ/RFP	3	5	5	5	5	3	4.3	
d.	Consultant is required to identify exceptions to the contract form or content at the time of submittal in response to RFQ/RFP	3	5	5	1	1	0	2.5	
e.	The PW Director/City Engineer has authority to approve consulting contracts with justification. (0 for none, 1 for <$10^k, 2 for 10^k - 25^k, 3 for 25k - 50k, 4 for 50k - 100k,5 for >100^k)	0	0	4	5	5	4	3.0	
f.	An Annual RFQ/RFP solicitation is used to develop an on-call list of pre-approved consultants	1	4	3	5	1	4	3.0	SJ: every 2 years
g.	There is a consultant use rating system that identifies quality of consultant performance	5	0	0	4	0	0	1.5	
h.	The consultant selection process is qualification based	5	5	5	5	5	5	5.0	
i.	Consultants can be sole-sourced, with justification	1	5	5	5	5	4	4.2	
j.	When are consultants required to provide the fee proposal? (At the time of initial proposal, or after the qualifications based selection.)								LA: After selection; LB: After selection; SC: facilities at initial proposal, transportation after selection; SD: After; SF: Sealed envelop at the time of proposal submittal.; SJ: After QBS
k.	Consultant fees are most often based on (1) Percentage of construction cost, (2) Lump Sum, (3) Loaded Hourly Rates								LA: (3); LB: (3); SC: (3); SD: (1); SF: (2); SJ: (2)
l.	Consultant fees are negotiated based on comparison with other proposals or are negotiated blind								LA: Comparison; LB: Compared to city estimate; SC: Comparisons w/similar projects; SD: Blind; SF: Negotiated Blind; SJ: Blind

D-I. Performance Questionnaire Form

California Multi-Agency CIP
Benchmarking Study
PERFORMANCE QUESTIONNAIRE

Agency: ____________ Project Name: ____________

Project type: ____________

Project Index: New / Rehab.: ____________ Complexity: ____________

Justification[(1)]: ____________

Description: ____________

Comments: ____________

	Planning		Design		Construction		Total	
	DOLLAR	% of TCC*	DOLLAR	% of TCC*	DOLLAR	% of TCC*	DOLLAR	% of TCC*
AGENCY LABOR								
AGENCY COSTS[(2)]								
Art Fees								
SUB-TOTAL AGENCY								
CONSULTANT								
TOTALS								
PHASE DURATION	Months		Months		Months			

AMOUNT OF CONSTRUCTION CONTRACT	
COST OF CHANGE ORDERS	
UTILITY RELOCATION COST	
CITY FORCES CONSTRUCTION	
* **TOTAL CONSTRUCTION COST (TCC)**	
LAND ACQUISITION	

(1) Justification for Complexity Index, if it is not "Normal"

(2) Agency costs include other direct costs and can be listed underneath. This value is locked and it is calculated from its items (Rows 14 - 18)

D-II. Performance Data

PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency A: Department of AAA

Municipal Facilities

Libraries

LIBRARY_01	Normal	New	53	489,084	404,028	5,129,808

1. This time duration (53 months) is overall time duration. Starting Date: Oct. 1997. Completion Date: March 2002. 2. Total duration could not be segregated and is shown as "Construction Duration".

LIBRARY_02	Normal	New	55	897,746	474,889	4,681,950

1. This time duration (55 months) is overall time duration. Starting Date: June 1991. Completion Date: January 1996. 2. Total duration could not be segregated and is shown as "Construction Duration".

LIBRARY_03	Normal	New	33	866,430	332,781	2,619,572

1. This time duration (33 months) is overall time duration. Starting Date: Oct. 1993. Completion Date: July 1996. 2. Total duration could not be segregated and is shown as "Construction Duration".

LIBRARY_04	Normal	New	85	396,377	617,964	2,329,727

1. This time duration (85 months) is overall time duration. Starting Date: May 1990. Completion Date: May 1997. 2. Total duration could not be segregated and is shown as "Construction Duration".

Police / Fire Station

POLICE/FIRE_01	Normal	New	69	183,641	43,749	535,168

1. This time duration (69 months) is overall time duration. Starting Date: Feb. 1992. Completion Date: Oct. 1997. 2. Total duration could not be segregated and is shown as "Construction Duration".

POLICE/FIRE_02	Normal	New	74	103,582	240,934	1,563,777

1. This time duration (74 months) is overall time duration. Starting Date: Sep. 1995. Completion Date: Nov. 2001. 2. Total duration could not be segregated and is shown as "Construction Duration".

Community Bldg./Rec. Center/CC/Gym

COMM/REC/CC/GYM_01	Normal	New	58	1,596,000	431,226	5,745,774

1. This time duration (45 months) is overall time duration Starting Date: June, 1994. Completion Date: Mar. 1998. 2. Total duration could not be segregated and is shown as "Construction Duration".

COMM/REC/CC/GYM_02	Normal	New	111	1,854,262	534,000	9,110,021

1. This time duration is overall time duration. Starting Date: Oct. 1990. Completion Date: Dec, 1999. 2. Total duration could not be segregated and is shown as "Construction Duration".

COMM/REC/CC/GYM_03	Normal	New	200	583,159	274,774	1,983,850

1. Project Starting Date: Oct. 1986. Project Completion Date: jul. 1999. 2. Total duration could not be segregated and is shown as "Construction Duration".

PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency A: Department of AAA

Streets

Widening / New / Grade Separation

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
WID/NEW/GRADE_01	Normal	Rehab	90	895,047	923,098	5,197,938

1. A portion of the planning costs is included in design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
WID/NEW/GRADE_02	Normal	Rehab	220	1,037,420	297,817	3,542,400

1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
WID/NEW/GRADE_03	Normal	Rehab	200	487,481	171,290	1,401,697

1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".

Bridges (Retrofit / Seismic)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_01	Normal	Rehab	35	74,752	8,006	53,664

1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_02	Normal	Rehab	25	86,019	8,382	62,722

1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_03	Normal	Rehab	55	74,403	6,977	235,350

1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_04	Normal	Rehab	60	78,632	42,923	109,892

1. A portion of the planning costs is included in the design costs This was an HBRR grant project. It required additional staff time to process paperwork. This impacted all projects with small construction costs. 2. Total dur could not be segregated.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_05	Normal	Rehab	80	90,786	71,421	401,664

1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_06	Normal	Rehab	120	80,540	25,624	72,502

1. A portion of the planning costs is included in the design costs This was an HBRR grant project. It required additional staff time to process paperwork. This impacted all project with small construction dollars. 2. Total dur. could not be segregated.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_07	Normal	Rehab	105	40,765	59,714	215,004

1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".

PROJECTS LISTING

Agency A: Department of AAA

Streets

Renovation / Resurfacing

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_01	Normal	Rehab	380	6,389	56,100	125,544
This project had additional "in-house" engineering charges due to insufficient funding in some signal projects. A portion of the planning costs are included in the design costs.						
RENOV/RESURF_02	Normal	Rehab	90	654	16,771	79,296
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
RENOV/RESURF_03	Normal	Rehab	90	10,246	21,570	67,116
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
RENOV/RESURF_04	Normal	Rehab	180	206,976	118,489	682,339
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
RENOV/RESURF_05	Normal	Rehab	180	5,509	19,906	49,235
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						

Bike / Pedestrian / Curb Ramps

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BIKE/PED/CURB_01	Normal	New	242	0	26,255	140,666
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
BIKE/PED/CURB_02	Normal	Rehab	198	22,778	42,433	48,079
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
BIKE/PED/CURB_03	Normal	New	45	20,099	12,380	23,231
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
BIKE/PED/CURB_04	Normal	Rehab	748	16,187	3,924	17,022
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
BIKE/PED/CURB_05	Normal	New	240	45,999	31,683	124,841
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						

PROJECTS LISTING

Agency A: Department of AAA

Streets

Bike / Pedestrian / Curb Ramps

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BIKE/PED/CURB_06	Normal	Rehab	180	36,125	75,492	296,971
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
BIKE/PED/CURB_07	Normal	New	176	26,534	21,944	35,750
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						

Signals

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
SIGNAL_01	Normal	New	300	27,417	39,919	151,257
A portion of the planning costs is included in the design costs						
SIGNAL_02	Normal	New	380	20,422	45,719	83,789
A portion of the planning costs is included in the design costs						
SIGNAL_03	Complex	New	290	12,919	45,654	152,504
A portion of the planning costs is included in the design costs						
SIGNAL_04	Normal	New	285	48,416	36,362	139,284
A portion of the planning costs is included in the design costs						
SIGNAL_05	Normal	New	320	36,778	43,869	138,047
A portion of the planning costs is included in the design costs.						
SIGNAL_06	Normal	Rehab	470	41,173	54,348	305,509
A portion of the planning costs is included in the design costs.						
SIGNAL_07	Normal	New	290	30,809	50,274	129,193
A portion of the planning costs is included in the design costs.						
SIGNAL_08	Normal	New	250	8,160	18,754	64,500
A portion of the planning costs is included in the design costs.						
SIGNAL_09	Normal	New	400	29,627	32,024	103,642
A portion of the planning costs is included in the design costs.						
SIGNAL_10	Normal	New	410	16,899	66,661	138,754
A portion of the planning costs is included in the design costs.						

California Multi-Agency CIP Benchmarking Study

PROJECTS LISTING

Agency A: Department of AAA

Pipe Systems

Gravity System (Storm Drains, Sewers)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
GRAVITY_01	Normal	Rehab	264	161,700	45,115	206,123
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_02	Normal	Rehab	352	31,933	1,500	52,263
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_03	Normal	Rehab	616	63,135	16,669	63,267
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_04	Normal	Rehab	264	68,339	52,574	453,669
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_05	Normal	Rehab	264	59,310	5,147	84,666
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_06	Normal	Rehab	484	24,270	20,758	35,300
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_07	Normal	Rehab	45	9,706	28,621	89,746
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_08	Normal	Rehab	308	5,165	19,412	43,400
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_09	Normal	Rehab	396	82,664	7,499	241,726
1. A portion of the planning costs is included in the design costs. 2. Total duration could not be segregated and is shown as "Construction Duration".						
GRAVITY_10	Normal	New	82	99,519	47,855	205,775
Project design was on hold due to lack of project funding						
GRAVITY_11	Normal	New	63	148,718	82,140	781,700
GRAVITY_12	Complex	New	52	348,372	113,095	1,153,907

California Multi-Agency CIP Benchmarking Study
PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency A: Department of AAA
Pipe Systems
Gravity System (Storm Drains, Sewers)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
GRAVITY_13	Normal	New	47	146,783	185,532	934,624
GRAVITY_14	Normal	New	42	120,743	66,187	689,876
GRAVITY_15	Normal	New	22	74,452	134,842	1,805,797

Pressure Systems

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
PRESSURE_01	Normal	New	57	134,177	65,930	472,751
PRESSURE_02	Normal	New	78	155,433	84,478	816,716
Project on hold three years due to lack of project funding.						
PRESSURE_03	Normal	New	82	216,113	95,837	1,521,547
Project design was on hold due to lack of project funds						
PRESSURE_04	Normal	New	30	112,410	238,625	976,793
PRESSURE_05	Normal	New	66	156,480	160,961	1,298,215
Project delayed 2-1/2 years due to lack of project funding.						
PRESSURE_06	Normal	New	60	113,012	79,975	652,084
PRESSURE_07	Normal	New	45	56,214	55,331	264,558

Pump Stations

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
PUMP STN_01	Normal	New	17	512,954	348,556	1,710,697
Total duration could not be segregated and is shown as "Construction Duration".						
PUMP STN_02	Normal	New	23	482,920	370,820	3,418,235
Total duration could not be segregated and is shown as "Construction Duration".						

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency B: Department of BBB

Municipal Facilities

Libraries

LIBRARY_01	Normal	Rehab	13	87,225	42,909	208,365

Quality control code inspection costs are included in the agency labor/construction phase. Architectural services were performed in-house.

Police / Fire Station

POLICE/FIRE_01	Normal	Rehab	12	244,190	192,263	3,003,823

Quality control code inspection costs are included in the agency labor/construction phase.

Community Bldg./Rec. Center/CC/Gym

COMM/REC/CC/GYM_01	Normal	New	20.5	390,593	203,736	2,223,489

Quality control code inspection costs are included in the agency labor/construction phase.

COMM/REC/CC/GYM_02	Normal	New	29	1,276,939	309,281	9,122,123

Quality control code inspection costs are included in the agency labor/construction phase.

Streets

Widening / New / Grade Separation

WID/NEW/GRADE_01	Normal	New	96	4,083,586	1,626,953	15,799,724
WID/NEW/GRADE_02	Normal	New	44	215,484	64,120	1,158,735

$14,972 Administration/Other costs were added to Agency Labor - Planning costs.

WID/NEW/GRADE_03	Normal	New	93	706,529	985,029	15,920,570

The project will also connect with XXX Road

WID/NEW/GRADE_04	Normal	New	64	749,676	1,486,681	10,095,550

$14,149 Administration/Other costs were added to Agency Labor - Planning costs. Multiple vendors and doesn't reflect contribution from RT.

WID/NEW/GRADE_05	Normal	Rehab	20	306,655	85,069	1,167,879

$22,000 Administration/other costs were added to Agency Labor - Planning Costs

WID/NEW/GRADE_06	Normal	New	32	126,614	65,520	948,954

$10,000 Administration/Other costs were added to Agency Labor - Planning costs.

WID/NEW/GRADE_07	Normal	New	21	152,990	218,286	1,732,238

PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency B: Department of BBB

Streets

Widening / New / Grade Separation

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
WID/NEW/GRADE_08	Normal	New	36	36,376	298,702	6,516,132

Change order included new items added to project and changes to plans. $18,858 Administration/Other costs were added to Agency Labor - Planning costs. Design was done by a consultant contracted with XXXX.

Renovation / Resurfacing

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_01	Normal	Rehab	20	99,943	61,679	3,070,369

$56,455 Administration/Other costs were added to Agency Labor - Planning costs. Street Maintenance spent $310,722 on base repair plus labor costs. Change order for $107,630 to reconstruct a segment of XXX St due to unsuitable material.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_02	Normal	Rehab	17	147,404	87,841	3,645,850

Project was completed in two phases. Street maintenance spent approx. $200,000 on base repair and labor costs. $62,951 Administration/Other costs were added to Agency Labor - Planning costs.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_03	Normal	Rehab	17	109,725	71,178	677,306
RENOV/RESURF_04	Normal	Rehab	24	120,937	70,505	1,265,725

$11,200 Administration/Other costs were added to Agency Labor - Planning costs.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_05	Normal	Rehab	19	28,425	29,700	501,234

$24,013 Administration/Other costs were added to Agency Labor - Planning costs.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_06	Normal	Rehab	42	26,693	54,365	561,673

$1,686 Administration/Other costs were added to Agency Labor - Planning costs.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_07	Normal	Rehab	48	120,147	95,987	1,357,886

$2,281 Administration/Other costs were added to Agency Labor - Planning costs. Change order due to an additional scope of work.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_08	Normal	Rehab	20	97,508	84,118	1,183,359

$5,000 Administration/Other costs were added to Agency Labor - Planning costs.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
RENOV/RESURF_09	Normal	Rehab	27	125,548	120,837	1,089,040

Bike / Pedestrian / Curb Ramps

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BIKE/PED/CURB_01	Complex	New	26	746,569	165,068	2,456,831

$3,946 Administration/Other costs were added to Agency Labor - Planning costs.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BIKE/PED/CURB_02	Normal	New	15	77,653	97,028	1,216,293

$3,181 Administration/Other costs were added to Agency Labor - Planning costs.

PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency B: Department of BBB

Streets

Bike / Pedestrian / Curb Ramps

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BIKE/PED/CURB_03	Normal	New	11	16,245	18,083	493,290
$1,000 Administration/Other costs were added to Agency Labor - Planning costs.						
BIKE/PED/CURB_04	Normal	New	11	23,308	64,282	1,136,830
$815 Administration/Other costs were added to Agency Labor - Planning costs.						
BIKE/PED/CURB_05	Normal	New	10	3,504	32,105	248,360
$3,161 Administration/Other costs were added to Agency Labor - Planning costs.						
BIKE/PED/CURB_06	Normal	New	12	28,303	8,168	49,670
$3,957 Administration/Other costs were added to Agency Labor - Planning costs.						
BIKE/PED/CURB_07	Normal	New	10	9,044	3,308	11,230

Signals

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
SIGNAL_01	Normal	New	5	27,540	4,969	139,568
$4,712 Administration/Other costs were added to Agency Labor - Planning costs.						
SIGNAL_02	Normal	New	6	7,499	6,980	84,805
SIGNAL_03	Normal	New	19.5	27,055	4,888	83,163
$5,331 Administration/Other costs were added to Agency Labor - Planning costs.						
SIGNAL_04	Normal	New	7.5	36,883	4,700	113,524
$12,483 Administration/Other costs were added to Agency Labor - Planning costs.						
SIGNAL_05	Normal	New	9	52,660	32,176	188,253
$6,019 Administration/Other costs were added to Agency Labor - Planning costs.						

Agency C: Department of CCC

Municipal Facilities

Libraries

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
LIBRARY_01	Normal	Rehab	28	578,249	490,199	2,356,523
LIBRARY_02	Normal	New	21	328,000	263,000	1,326,932
Project delivered in a short amount of time in order to satisfy community expectations.						

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency C: Department of CCC

Municipal Facilities

Police / Fire Station

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
POLICE/FIRE_01	Complex	New	41	1,019,065	903,107	8,458,635
POLICE/FIRE_02	Normal	Rehab	27	362,191	412,415	2,564,618
POLICE/FIRE_03	Normal	Rehab	57	653,674	762,120	4,612,694
POLICE/FIRE_04	Normal	Rehab	24	307,853	166,327	927,411
POLICE/FIRE_05	Normal	Rehab	25	512,000	253,000	1,978,404
POLICE/FIRE_06	Normal	Rehab	50	1,016,247	393,952	3,713,333

Community Bldg./Rec. Center/CC/Gym

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
COMM/REC/CC/GYM_01	Normal	Rehab	46	198,028	106,569	611,500
COMM/REC/CC/GYM_02	Complex	Rehab	92	154,104	64,229	324,002

Client requested 3 completed preliminary schemes and two sets of construction documents for their own construction crew. Project was on hold for four years and repackaged for bids.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
COMM/REC/CC/GYM_03	Complex	New	96	818,918	637,836	4,841,582

Extended planning (lawsuits, death of Architect). Bad General Contractor - delivered building one year late.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
COMM/REC/CC/GYM_04	Complex	New	36	371,422	443,703	3,349,008

Inexperienced Contractor. Client requested 10 full preliminary schemes.

Streets

Widening / New / Grade Separation

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
WID/NEW/GRADE_01	Complex	New	42	156,821	125,923	904,926

Construction restrictions due to traffic operations and addressing the needs of hotels and merchants and public events, as well as the high number of utilities relocation.

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
WID/NEW/GRADE_02	Complex	Rehab	79	510,000	917,500	5,492,000

path and sewer line. These project were redesigned and readvertised, combined project with street widening.

PROJECTS LISTING

Agency C: Department of CCC

Streets

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
Widening / New / Grade Separation						
WID/NEW/GRADE_03	Normal	New	61	441,732	211,426	2,851,125
WID/NEW/GRADE_04	Normal	New	23	85,680	85,752	237,815
Bridges (Retrofit / Seismic)						
BRDG/RETRO/SEISMIC_01	Complex	Rehab	57	2,795,613	993,769	11,474,673
BRDG/RETRO/SEISMIC_02	Normal	Rehab	24	126,004	93,977	847,280
BRDG/RETRO/SEISMIC_03	Normal	Rehab	11	34,007	22,672	242,585
BRDG/RETRO/SEISMIC_04	Normal	New	38	475,417	396,573	2,734,019
Renovation / Resurfacing						
RENOV/RESURF_01	Normal	Rehab	48	207,429	260,914	1,303,466
RENOV/RESURF_02	Normal	Rehab	55	101,747	171,401	883,469
RENOV/RESURF_03	Normal	Rehab	23	112,586	133,129	812,728
RENOV/RESURF_04	Normal	Rehab	45	91,668	145,316	1,114,209
RENOV/RESURF_05	Normal	Rehab	44	91,921	195,001	1,651,477
RENOV/RESURF_06	Normal	Rehab	16	135,535	125,268	823,699
RENOV/RESURF_07	Normal	Rehab	24	114,572	185,164	937,092

PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
Agency C: Department of CCC						
Streets						
Bike / Pedestrian / Curb Ramps						
BIKE/PED/CURB_01	Normal	Rehab	4	23,000	23,580	133,240
BIKE/PED/CURB_02	Normal	New	7.5	27,261	22,350	173,725
BIKE/PED/CURB_03	Normal	New	6.5	40,138	48,110	317,930
BIKE/PED/CURB_04	Normal	New	6.5	26,000	26,000	173,375
Signals						
SIGNAL_01	Normal	New	19	45,000	76,600	433,000
SIGNAL_02	Normal	New	33	46,850	123,888	700,606
SIGNAL_03	Normal	Rehab	38	67,101	97,522	625,800
SIGNAL_04	Normal	Rehab	42	131,812	165,936	1,050,000
SIGNAL_05	Normal	New	27	95,200	67,900	452,000
SIGNAL_06	Normal	Rehab	27	94,000	123,268	803,000
SIGNAL_07	Normal	Rehab	44	77,184	130,278	997,258
Pipe Systems						
Gravity System (Storm Drains, Sewers)						
GRAVITY_01	Normal	Rehab	5	68,477	63,159	1,627,027

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency C: Department of CCC

Pipe Systems

Gravity System (Storm Drains, Sewers)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
GRAVITY_02	Normal	New	16.5	80,038	66,678	695,024
GRAVITY_03	Normal	Rehab	43	237,398	485,374	2,863,966
GRAVITY_04	Normal	New	23	49,900	59,967	525,985
GRAVITY_05	Complex	New	4.5	34,101	33,054	458,145
GRAVITY_06	Normal	Rehab	20	66,440	91,000	796,440
GRAVITY_07	Normal	Rehab	29	77,978	87,430	856,593

This is a JV with XXX. Amount shown is for sewer work only.

Pressure Systems

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
PRESSURE_01	Normal	New	26	382,792	158,805	1,880,219
PRESSURE_02	Normal	Rehab	23	75,842	157,645	1,824,447
PRESSURE_03 *PUC project.*	Normal	Rehab	23	69,241	55,941	1,044,177
PRESSURE_04 *PUC Project.*	Normal	Rehab	21	92,384	125,793	1,276,649
PRESSURE_05 *PUC Project.*	Normal	Rehab	14	45,493	41,096	493,835
PRESSURE_06 *PUC Project.*	Normal	Rehab	21	53,654	229,363	840,520

Pump Stations

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
PUMP STN_01	Normal	New	22	664,036	532,412	3,301,000

PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
Agency C: Department of CCC						
Pipe Systems						
Pump Stations						
PUMP STN_02	Normal	Rehab	40	1,410,624	976,000	7,539,700
PUMP STN_03	Normal	New	33	942,110	313,700	8,290,000
PUMP STN_04	Normal	New	36	1,291,338	857,300	7,418,700
PUMP STN_05	Normal	New	27	525,142	539,523	2,998,362
PUMP STN_06	Normal	New	26	251,229	435,011	2,916,300
Agency D: Department of DDD						
Municipal Facilities						
Libraries						
LIBRARY_01 *E1700027*	Normal	New	96	565,725	377,815	2,102,680
LIBRARY_02 *E1700033*	Normal	New	60	810,081	312,388	3,831,000
LIBRARY_03 *E1700037*	Normal	New	80	484,083	403,495	2,685,000
LIBRARY_04 *E1700371*	Normal	New	38	581,278	7,122	3,352,000
LIBRARY_05 *E1700378*	Normal	New	39	533,801	448,548	2,246,000
LIBRARY_06 *E1700404 & E1700405*	Normal	New	40	708,021	7,482	2,933,750
Police / Fire Station						
POLICE/FIRE_01 *E1601083*	Complex	New	36	280,146	189,528	2,418,658

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
Agency D: Department of DDD						
Municipal Facilities						
Police / Fire Station						
POLICE/FIRE_02 *E1700061*	Normal	New	101	830,087	308,183	5,581,715
POLICE/FIRE_03 *E1700077*	Normal	New	100	2,156,900	450,678	10,932,961
POLICE/FIRE_04 *E1700078*	Normal	New	92	2,217,771	741,775	11,852,000
POLICE/FIRE_05 *E1700125*	Normal	New	97	4,179,499	855,166	28,041,026
POLICE/FIRE_06 *E1700168*	Normal	Rehab	80	217,320	88,440	912,762
POLICE/FIRE_07 *E1700175*	Normal	Rehab	55	190,034	72,191	1,569,803
Community Bldg./Rec. Center/CC/Gym						
COMM/REC/CC/GYM_01 *E1902939*	Normal	New	32	698,795	448,186	5,118,926
COMM/REC/CC/GYM_02 *E1903294*	Normal	New	27	261,995	105,709	1,226,848
COMM/REC/CC/GYM_03 *E1903955*	Normal	New	43	350,526	73,993	1,300,000
Streets						
Widening / New / Grade Separation						
WID/NEW/GRADE_01 *E6000442*	Normal	Rehab	49	110,171	67,299	836,360
WID/NEW/GRADE_02 *E6000450*	Complex	Rehab	82	679,423	208,625	1,974,900
WID/NEW/GRADE_03 *EXX81111*	Normal	Rehab	45	206,413	4,579	1,386,648

PROJECTS LISTING

Agency D: Department of DDD

Streets

Widening / New / Grade Separation

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
WID/NEW/GRADE_04 *EXX81115*	Normal	Rehab	45	280,935	2,011	1,208,719

Bridges (Retrofit / Seismic)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_01 *E6000178*	Complex	Rehab	53	571,519	310,169	4,911,890
BRDG/RETRO/SEISMIC_02 *E6000259*	Complex	Rehab	43	1,543,713	460,663	3,425,607
BRDG/RETRO/SEISMIC_03 *E6000371*	Complex	Rehab	44	976,179	220,720	6,138,128
BRDG/RETRO/SEISMIC_04 *E6000375*	Complex	Rehab	68	411,652	170,521	1,829,916
BRDG/RETRO/SEISMIC_05 *E6000385*	Complex	New	78	556,649	354,641	1,831,767
BRDG/RETRO/SEISMIC_06 *E6000401*	Complex	Rehab	69	1,071,973	464,665	9,512,346

Pipe Systems

Gravity System (Storm Drains, Sewers)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
GRAVITY_01 *E2000474*	Normal	New	103.3	346,594	485,280	6,864,900
GRAVITY_02 *E2000543*	Normal	New	150.1	285,297	556,887	7,959,332
GRAVITY_03 *E2000545*	Normal	New	107	293,188	1,060,012	13,176,400
GRAVITY_04 *E4000055*	Normal	New	161	232,924	74,588	342,937
GRAVITY_05 *E4000238*	Normal	New	62	37,585	12,249	56,632

Agency D: Department of DDD

Pipe Systems

Gravity System (Storm Drains, Sewers)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
GRAVITY_06 *E4000260*	Normal	New	54	96,057	36,308	212,627
GRAVITY_07 *EXX31479*	Normal	New	284.9	629,722	122,702	9,390,839
GRAVITY_08 *SZC11113*	Normal	New	33.13	210,182	252,437	3,674,245
GRAVITY_09 *SZC11138*	Normal	New	21.3	79,765	105,505	1,186,373
GRAVITY_10 *SZC11139*	Normal	New	25	133,059	91,655	1,057,564
GRAVITY_11 *SZC11190*	Normal	New	23.1	163,195	111,401	615,699
GRAVITY_12 *SZC11193*	Normal	New	23.8	366,236	127,813	1,553,475
GRAVITY_13 *SZS11143*	Normal	New	56	96,161	10,902	246,450
GRAVITY_14 *SZS11157*	Normal	New	32	39,921	20,113	87,154
GRAVITY_15 *Unit 196*	Normal	Rehab	49	133,067	85,897	473,613
GRAVITY_16 *Unit 202*	Normal	Rehab	38	70,973	78,052	794,023
GRAVITY_17 *Unit 221*	Normal	Rehab	38	54,709	35,493	612,167
GRAVITY_18 *Unit 235*	Normal	Rehab	38	55,246	48,046	638,552

California Multi-Agency CIP Benchmarking Study
PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
Agency D: Department of DDD						
Pipe Systems						
Gravity System (Storm Drains, Sewers)						
GRAVITY_19 *Unit 236*	Normal	Rehab	30.4	78,817	49,856	511,085
GRAVITY_20 *Unit 251*	Normal	Rehab	36	84,927	41,326	426,470
GRAVITY_21 *UNIT 266*	Normal	Rehab	38	104,144	74,361	711,774
Agency E: Department of EEE						
Streets						
Widening / New / Grade Separation						
WID/NEW/GRADE_01	Normal	New	52	1,232,649	3,593,462	8,121,841
WID/NEW/GRADE_02	Normal	New	42	1,340,946	153,566	4,366,026
Renovation / Resurfacing						
RENOV/RESURF_01	Normal	Rehab	22	34,595	68,448	378,211
RENOV/RESURF_02	Normal	Rehab	14	26,062	43,403	330,256
RENOV/RESURF_03	Normal	Rehab	13	141,575	61,530	260,047
RENOV/RESURF_04	Normal	Rehab	27	57,270	78,934	533,326
RENOV/RESURF_05	Normal	Rehab	16	61,704	69,345	414,672
RENOV/RESURF_06	Normal	Rehab	20	62,535	158,492	965,167
RENOV/RESURF_07	Normal	Rehab	11	66,551	129,075	718,779

PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency E: Department of EEE

Streets

Bike / Pedestrian / Curb Ramps

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BIKE/PED/CURB_01	Normal	New	5	0	38,583	218,430
No design costs could be found. An accounting change occurred in 1997 that may be the reason why some information was lost.						
BIKE/PED/CURB_02	Normal	New	3	15,205	45,758	149,880
BIKE/PED/CURB_03	Normal	New	6	17,656	45,034	268,557
BIKE/PED/CURB_04	Normal	New	5	42,800	21,497	167,468
BIKE/PED/CURB_05	Normal	New	6	12,615	20,548	161,864
BIKE/PED/CURB_06	Normal	New	7	13,522	44,851	149,423

Signals

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
SIGNAL_01	Normal	New	9	9,962	20,581	168,654
SIGNAL_02	Normal	New	8	7,316	26,472	147,960
SIGNAL_03	Normal	New	11	17,995	19,017	307,619
SIGNAL_04	Normal	New	16	14,576	26,843	158,638

Agency F: Department of FFF

Municipal Facilities

Libraries

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
LIBRARY_01	Normal	New	29	430,000	190,000	1,726,262

PROJECTS LISTING

Agency F: Department of FFF

Municipal Facilities

Police / Fire Station

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
POLICE/FIRE_01	Normal	New	43	511,000	300,000	4,392,000
Public Works coordinated Plan Review/Code Checks and Inspections Only. The project schedule Design and Construction budgets were managed by another agency						
POLICE/FIRE_02	Normal	Rehab	29	92,000	26,000	1,154,851
POLICE/FIRE_03	Normal	New	30	316,000	97,000	1,042,135

Community Bldg./Rec. Center/CC/Gym

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
COMM/REC/CC/GYM_01	Normal	Rehab	22	346,000	89,000	894,000
COMM/REC/CC/GYM_02	Complex	New	17	1,026,000	210,000	3,383,365

Streets

Bridges (Retrofit / Seismic)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
BRDG/RETRO/SEISMIC_01	Normal	New	59	1,076,568	881,380	4,826,358
Contract Awarded on 2/27/96, Final on 8/8/00						
BRDG/RETRO/SEISMIC_02	Normal	New	67	1,364,448	828,409	3,419,668
Contract Awarded on 4/20/99, Final on 6/8/01						

Signals

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
SIGNAL_01	Normal	New	22.5	154,896	79,027	859,099
Contract Awarded on 6/20/00, Final on 6/28/01						
SIGNAL_02	Normal	New	19	38,050	121,213	387,651
Contract Awarded on 3/28/00, Final on 8/3/01						
SIGNAL_03	Normal	New	15	35,654	99,984	423,458
Contract Awarded on 5/9/00, Final on 6/25/01						
SIGNAL_04	Normal	New	31.5	85,423	77,242	1,176,448
Contract Awarded on 6/30/98, Final on 5/12/00						

PROJECTS LISTING

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost

Agency F: Department of FFF

Streets

Signals

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
SIGNAL_05	Normal	New	35.5	19,084	168,898	372,712
Contract Awarded on 6/29/99, Final on 1/10/02						
SIGNAL_06	Complex	New	26	70,078	56,235	440,733
Contract Awarded on 5/11/99, Final on 10/9/00 UP Railroad Construction Improvements-Land Acquisition. Land Acquisition is really Other Costs related to UPUPRR Construction Improvements						

Pipe Systems

Gravity System (Storm Drains, Sewers)

Project Description	Complexity	New OR Rehab	Total Dur	Design Cost	Construction Management	Construction Cost
GRAVITY_01	Normal	Rehab	32	265,101	132,806	2,035,815
Contract Awarded on 6/1/99, Final on 6/7/01						
GRAVITY_02	Normal	Rehab	25	167,921	157,096	1,039,280
Contract Awarded on 4/13/99, Final on 8/22/00						
GRAVITY_03	Complex	Rehab	12	22,350	142,216	379,164
Contract Awarded on 8/8/00, Final on 8/30/01						
GRAVITY_04	Normal	New	31	39,991	21,174	65,946
Contract Awarded on 5/17/99, Final on 3/27/00						

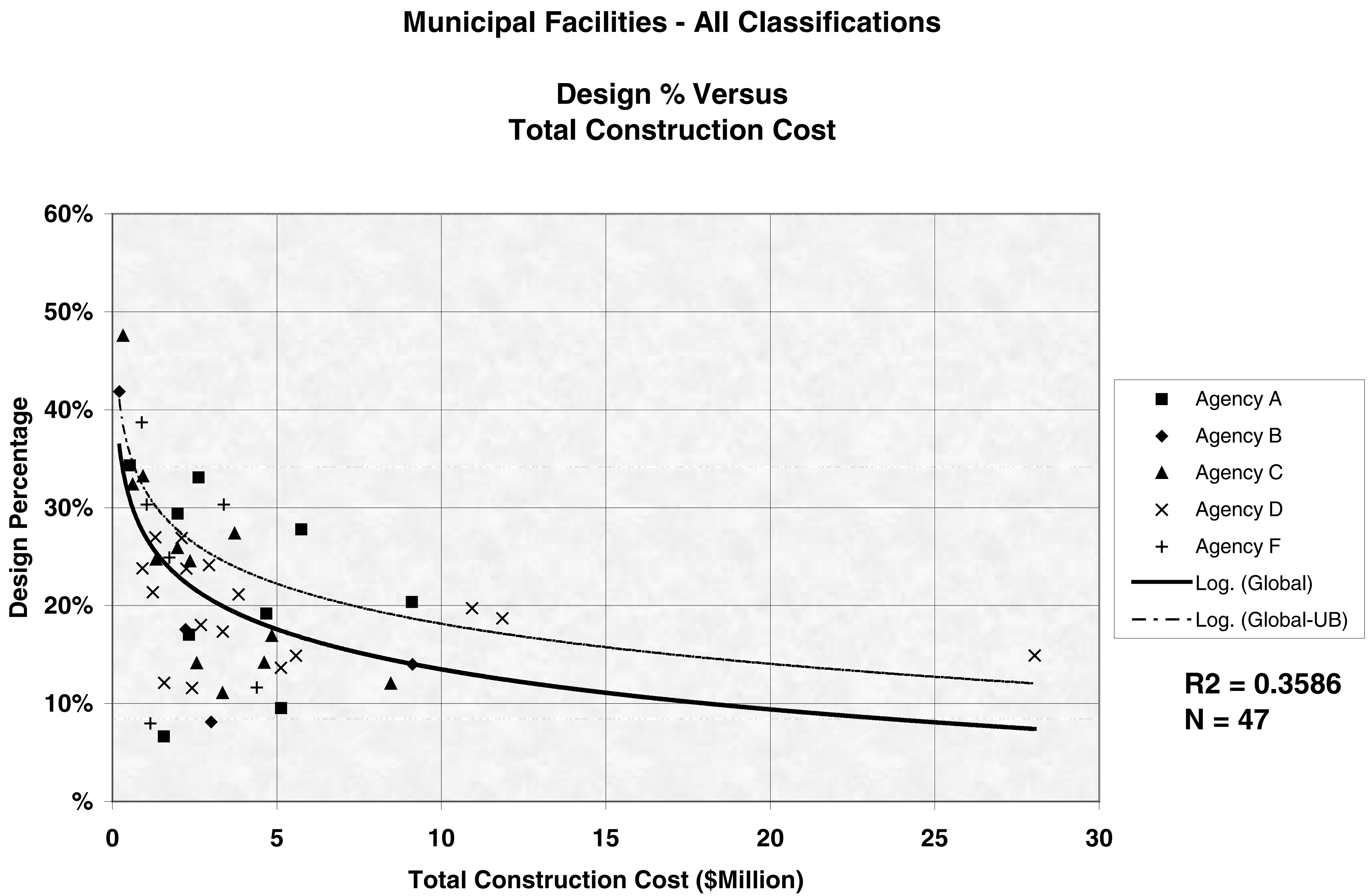
D-III. Performance Graphs

Curves Group 1

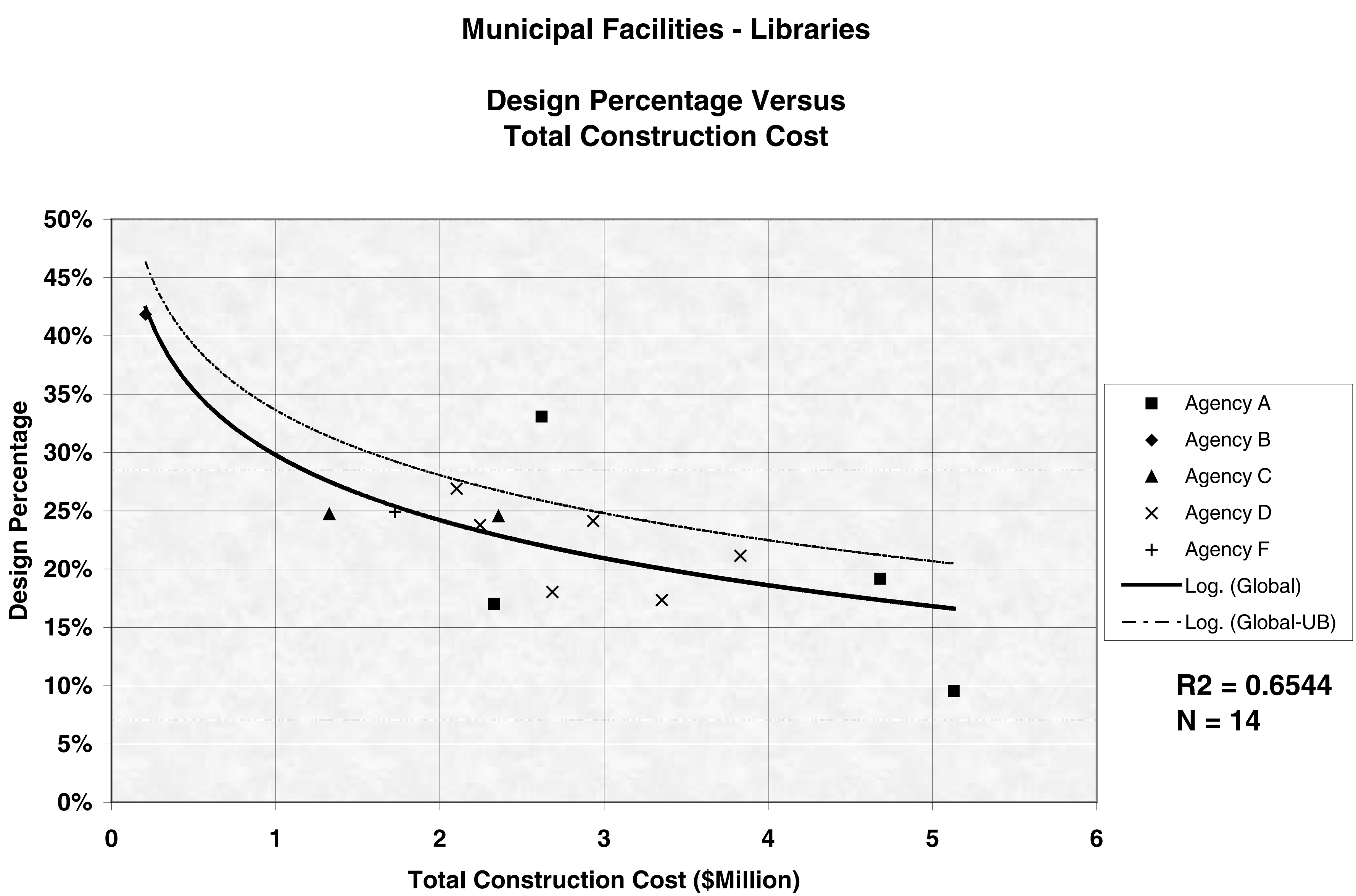
Design Cost / Construction Cost

Versus

Total Construction Cost

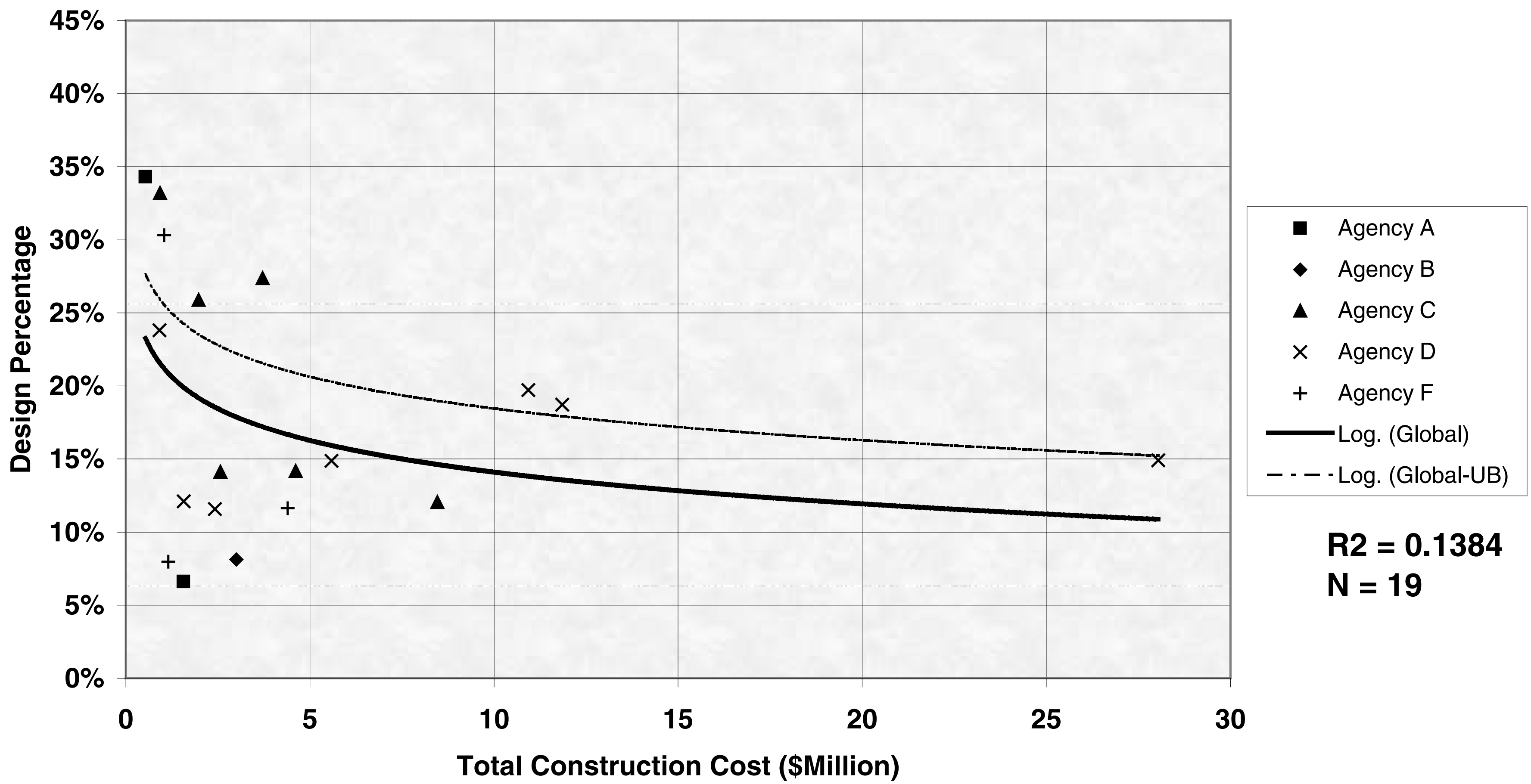


Municipal Facilities - All Classifications
Design % Versus
Total Construction Cost
60%
50%
40%
30%
20%
10%
%
0
5
10
15
20
25
30
Design Percentage
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency D
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.3586
N = 47


Municipal Facilities - Libraries
Design Percentage Versus
Total Construction Cost
Design Percentage
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
1
2
3
4
5
6
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency D
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.6544
N = 14

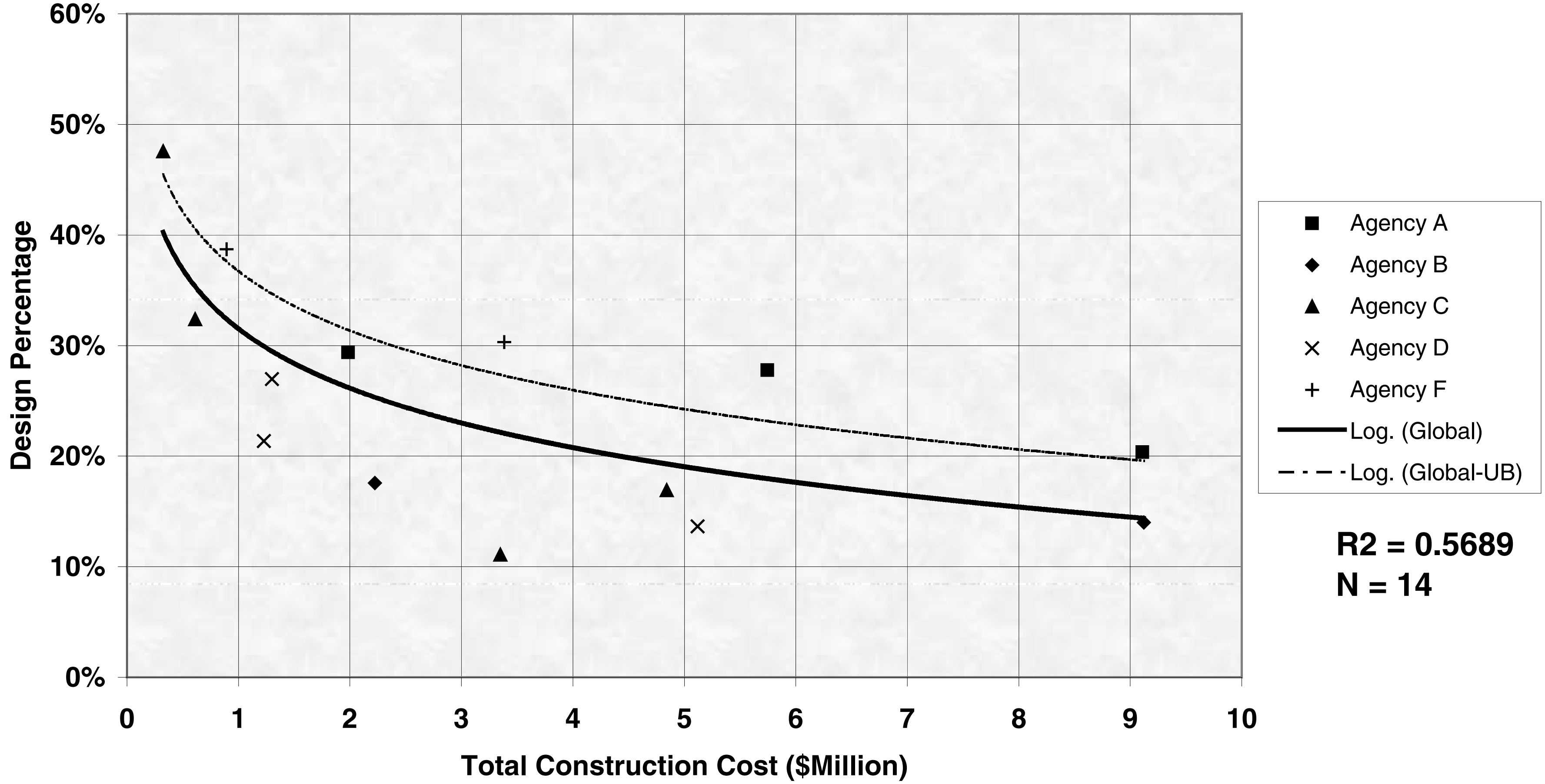
Municipal Facilities - Police / Fire Station

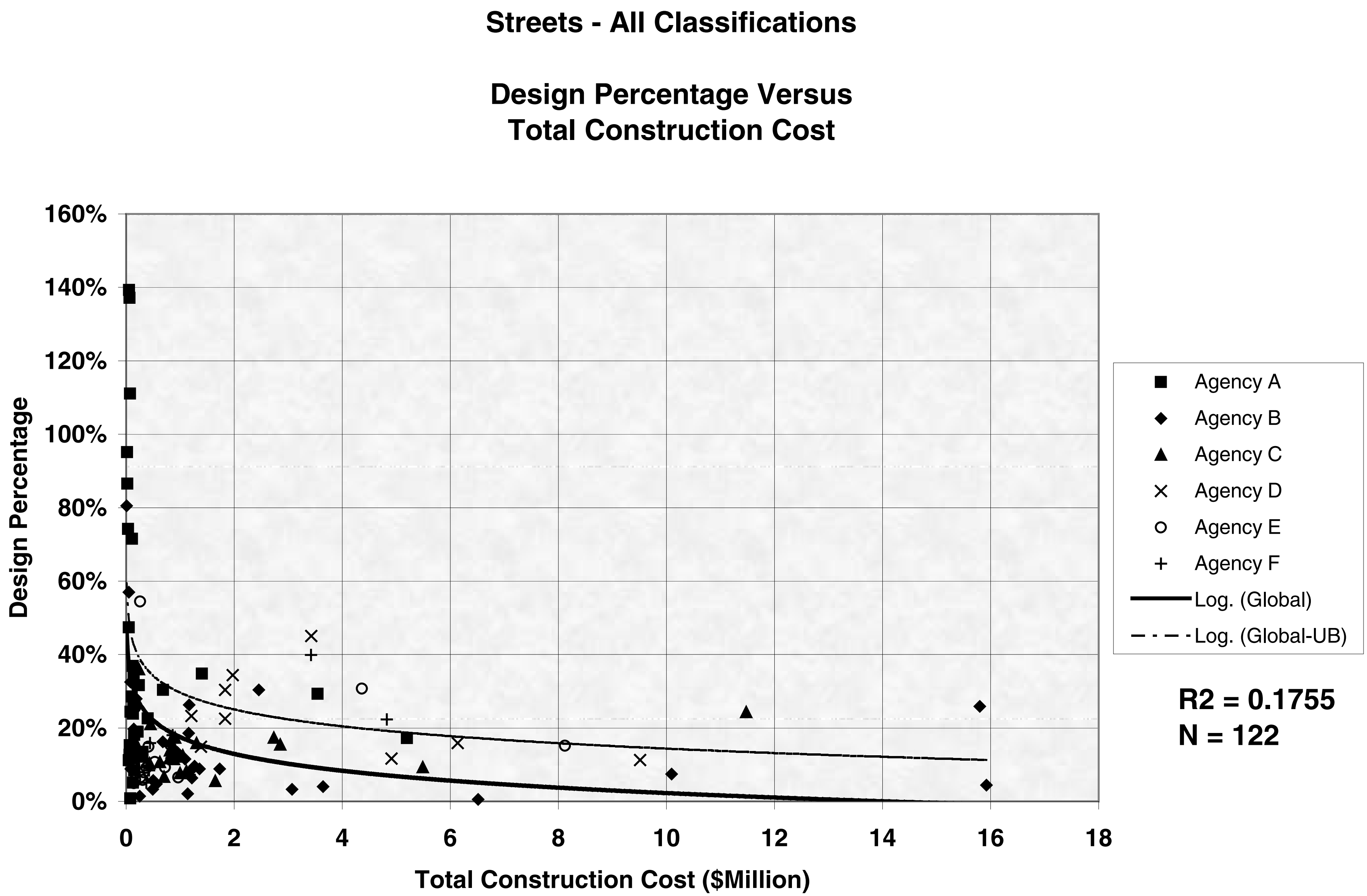
Design Percentage Versus
Total Construction Cost



Municipal Facilities - Community Bldg./Rec. Center/CC/Gym

Design Percentage Versus Total Construction Cost

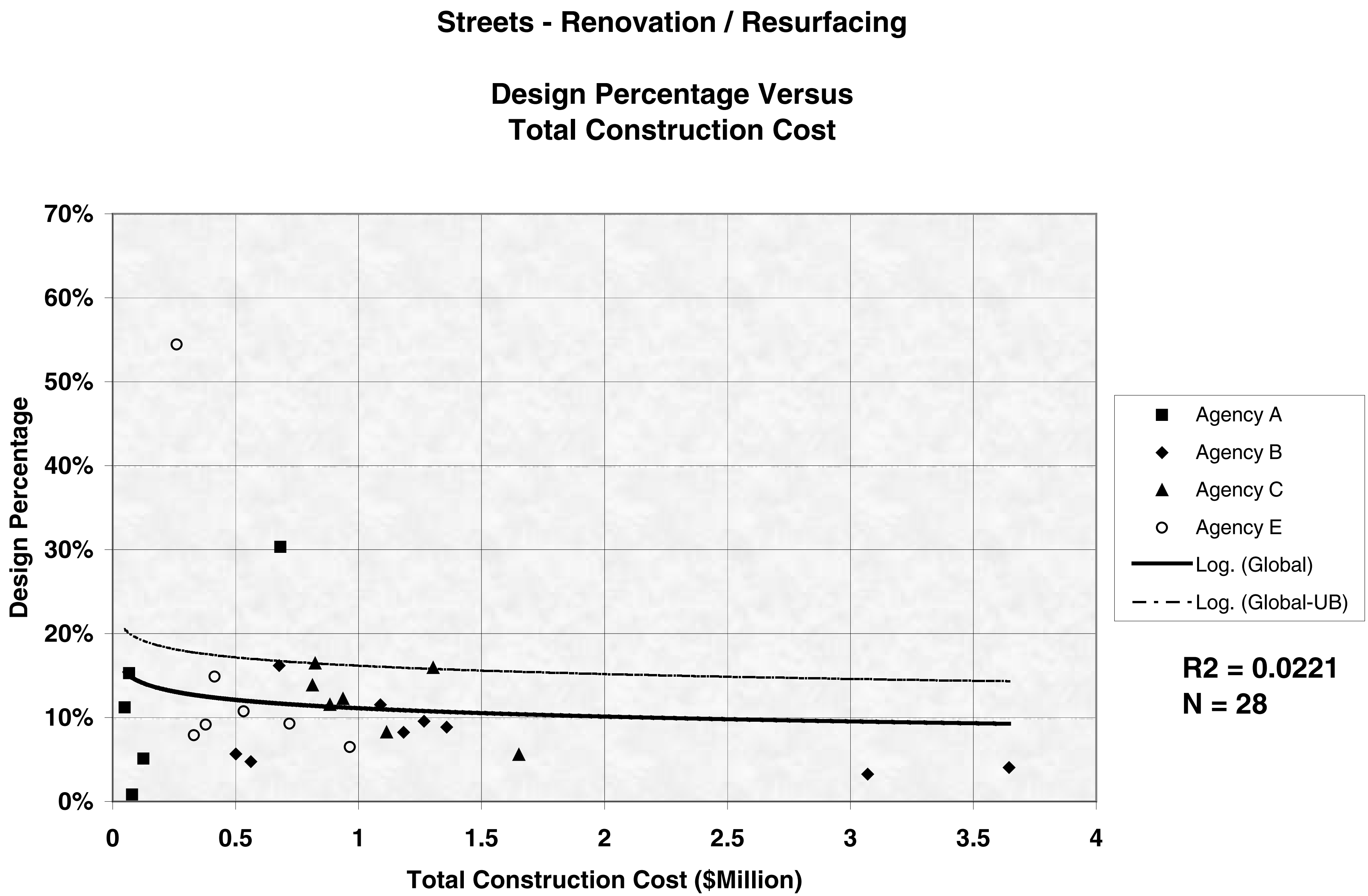


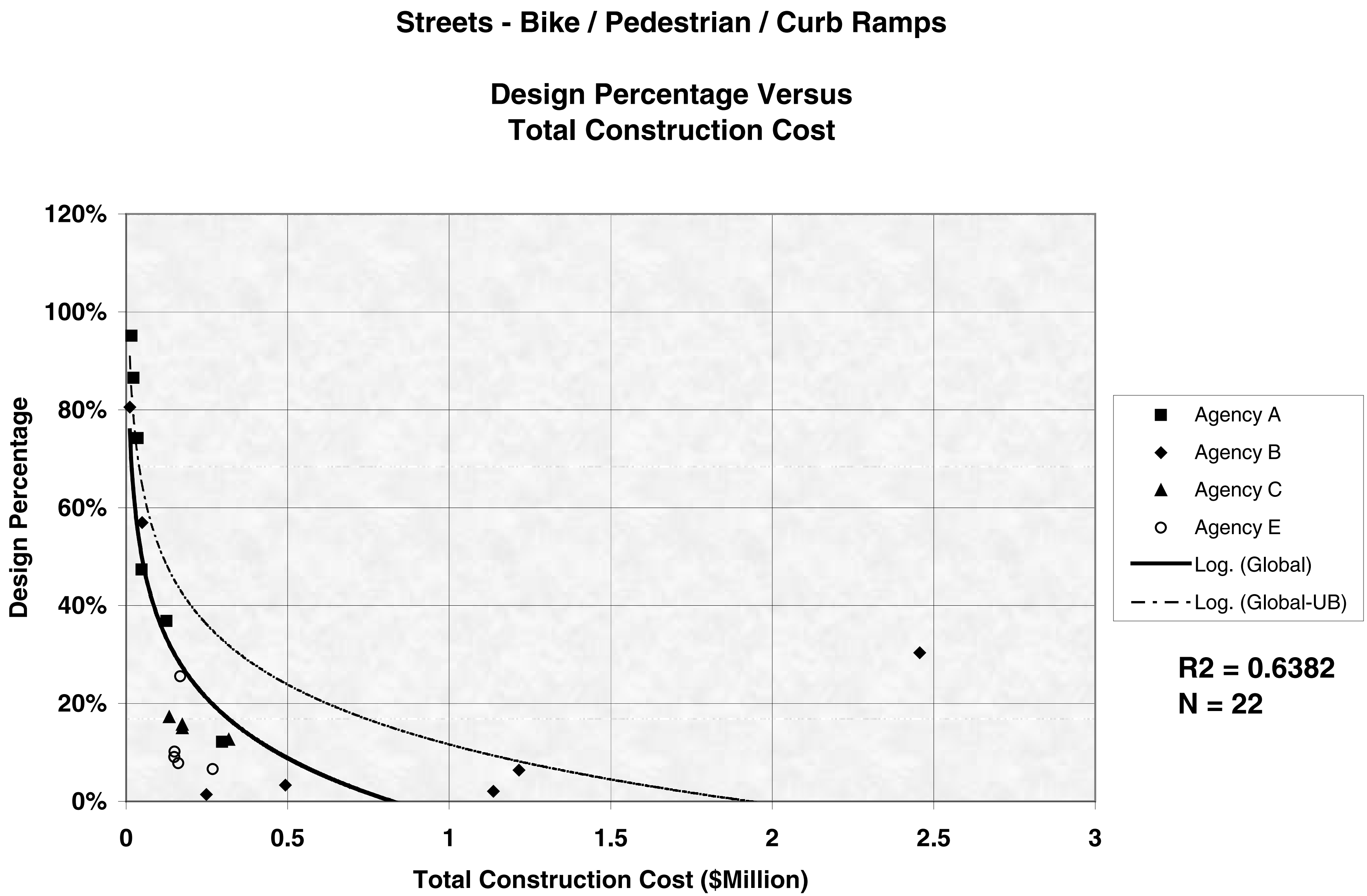


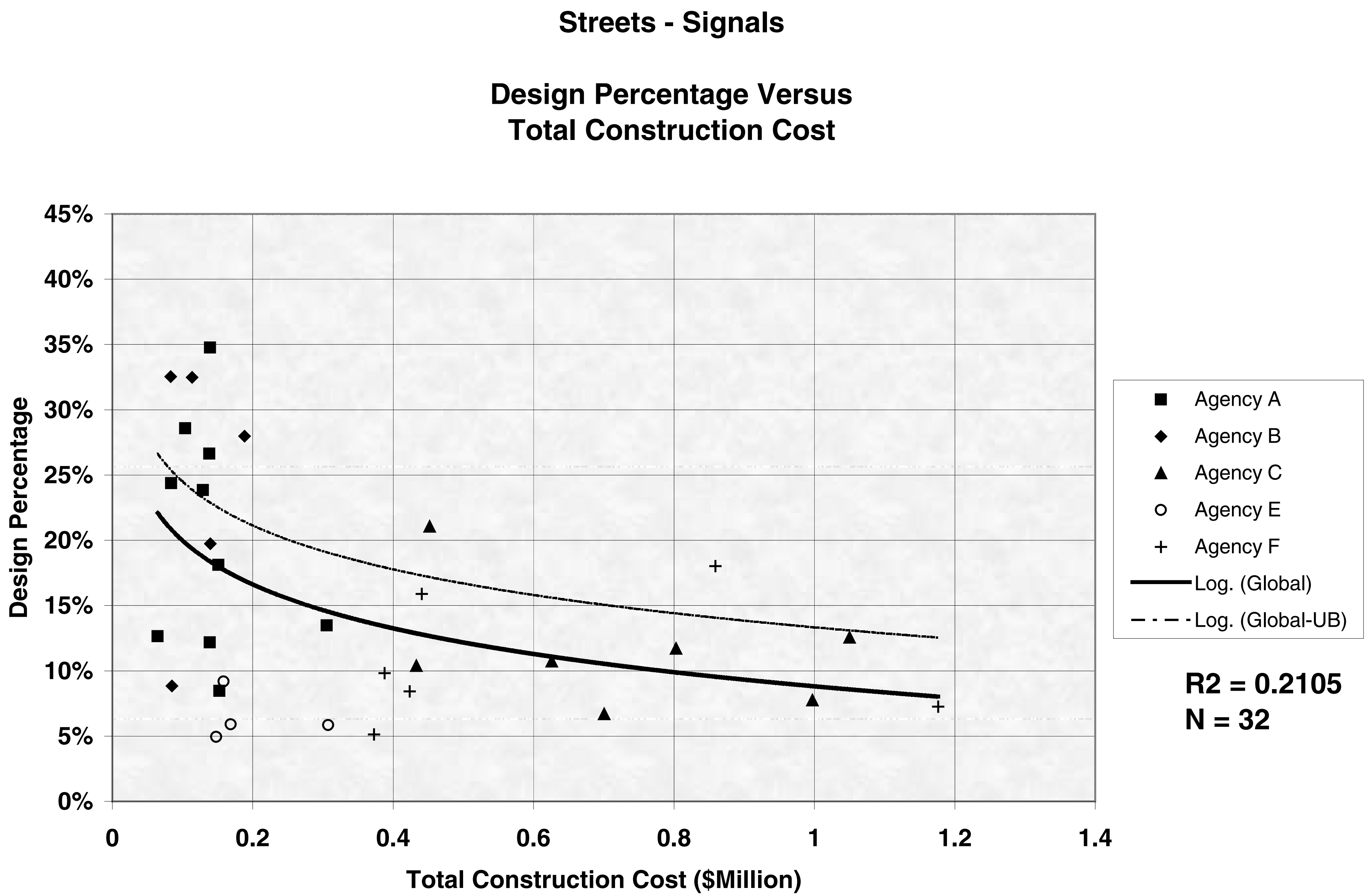
* Two Curb Ramp projects had zero design costs and were excluded from this graph


Streets - Widening / New / Grade Separation
Design Percentage Versus
Total Construction Cost
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Design Percentage
0
2
4
6
8
10
12
14
16
18
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency D
Agency E
Log. (Global)
Log. (Global-UB)
R2 = 0.1702
N = 21


Streets - Bridges (Retrofit / Seismic)
Design Percentage Versus
Total Construction Cost
Design Percentage
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
0
2
4
6
8
10
12
14
Total Construction Cost ($Million)
Agency A
Agency C
Agency D
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.5038
N = 19

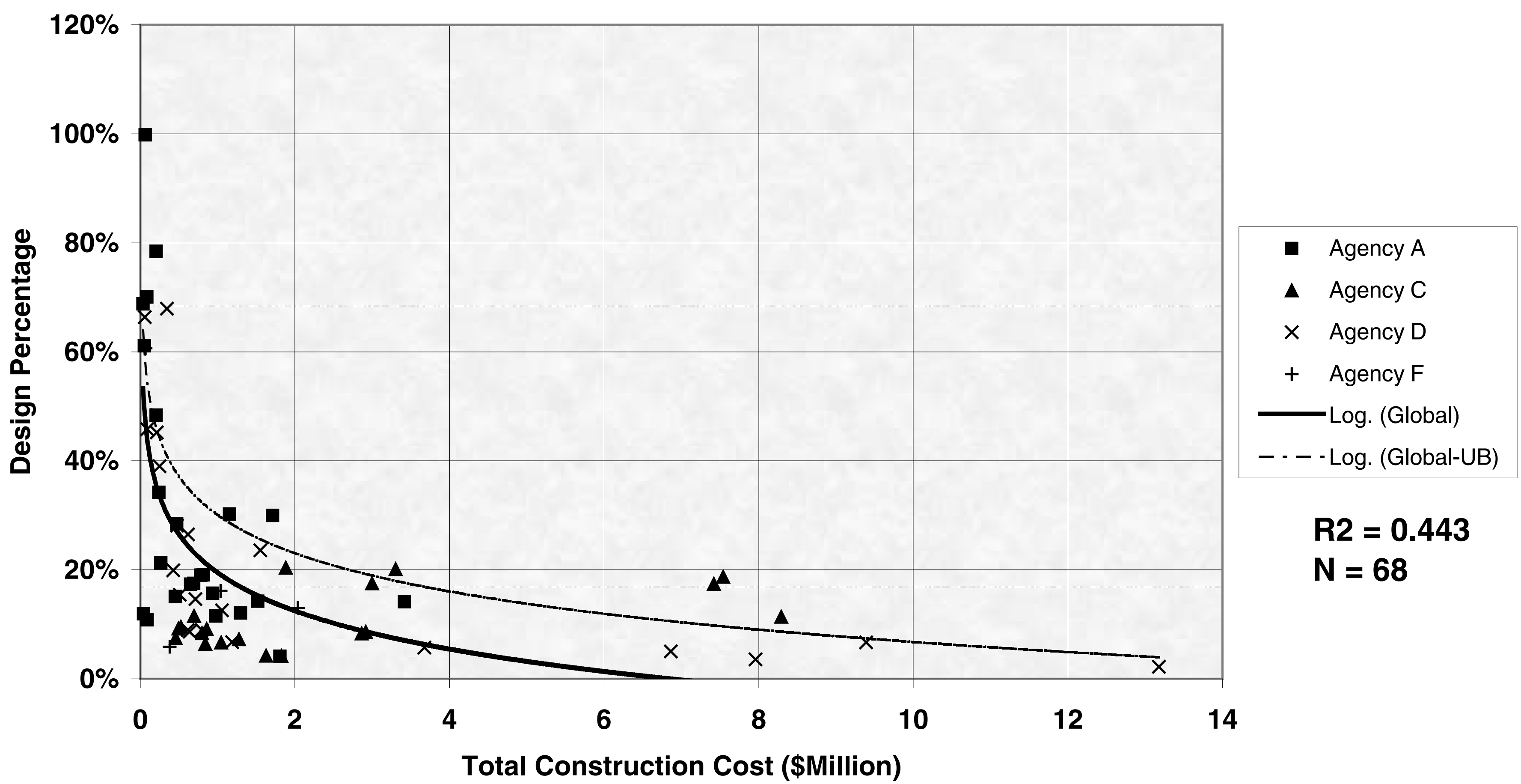

Streets - Renovation / Resurfacing
Design Percentage Versus
Total Construction Cost
70%
60%
50%
40%
30%
20%
10%
0%
Design Percentage
0
0.5
1
1.5
2
2.5
3
3.5
4
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency E
Log. (Global)
Log. (Global-UB)
R2 = 0.0221
N = 28


Streets - Bike / Pedestrian / Curb Ramps
Design Percentage Versus
Total Construction Cost
120%
100%
80%
60%
40%
20%
0%
Design Percentage
0
0.5
1
1.5
2
2.5
3
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency E
Log. (Global)
Log. (Global-UB)
R2 = 0.6382
N = 22


Streets - Signals
Design Percentage Versus
Total Construction Cost
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Design Percentage
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency E
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.2105
N = 32

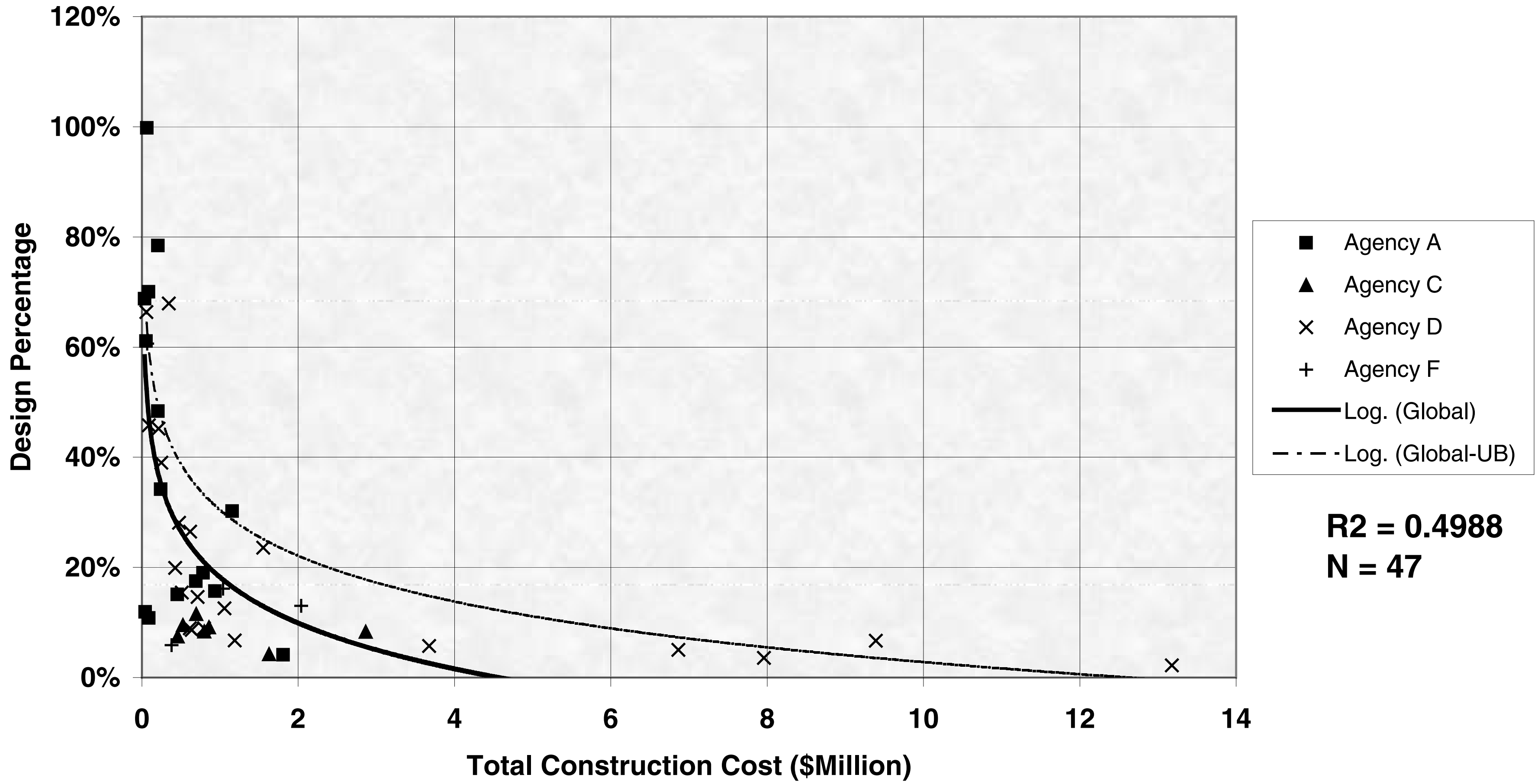
Pipe Systems - All Classifications

Design Percentage Versus Total Construction Cost



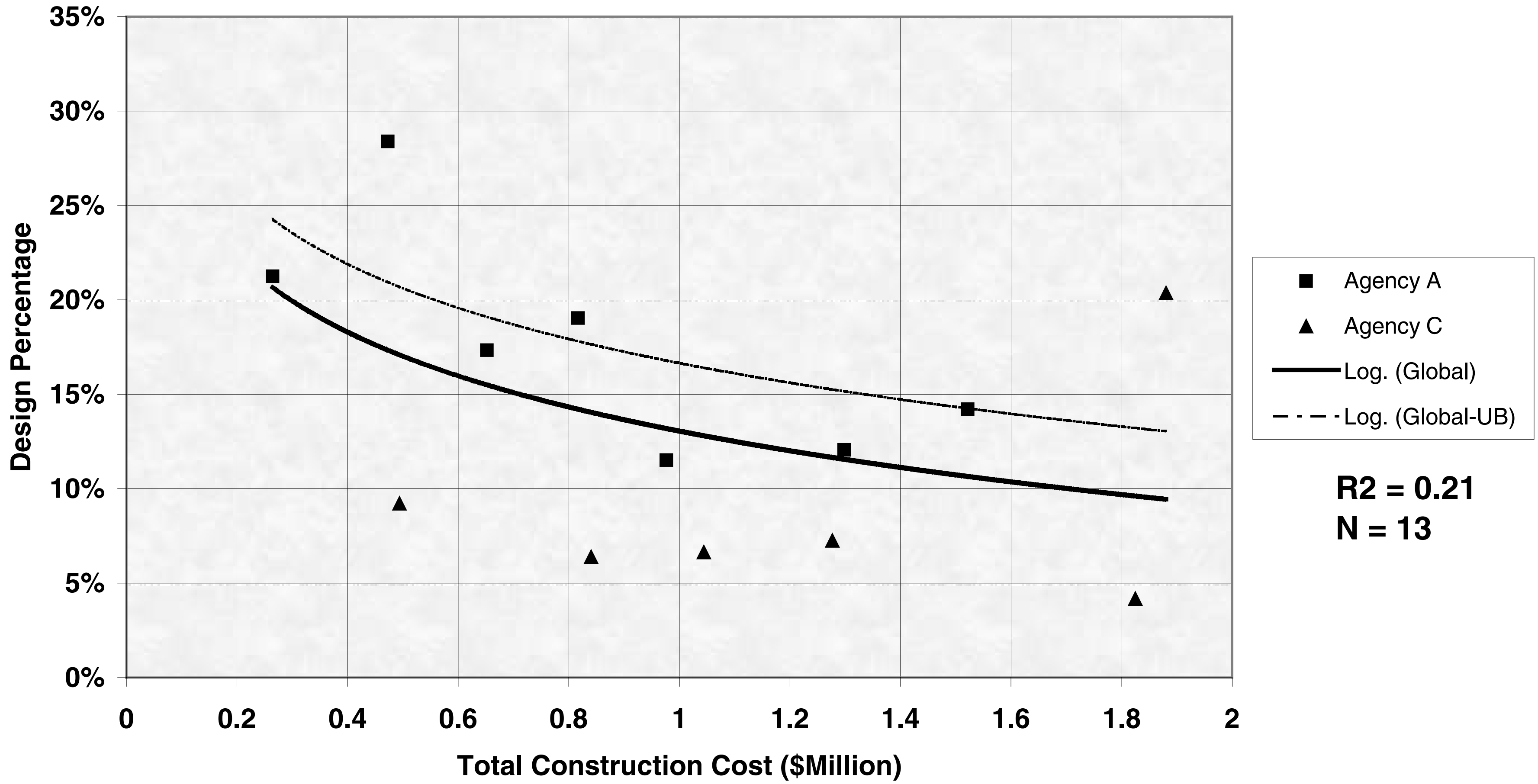
Pipe Systems - Gravity System (Storm Drains, Sewers)

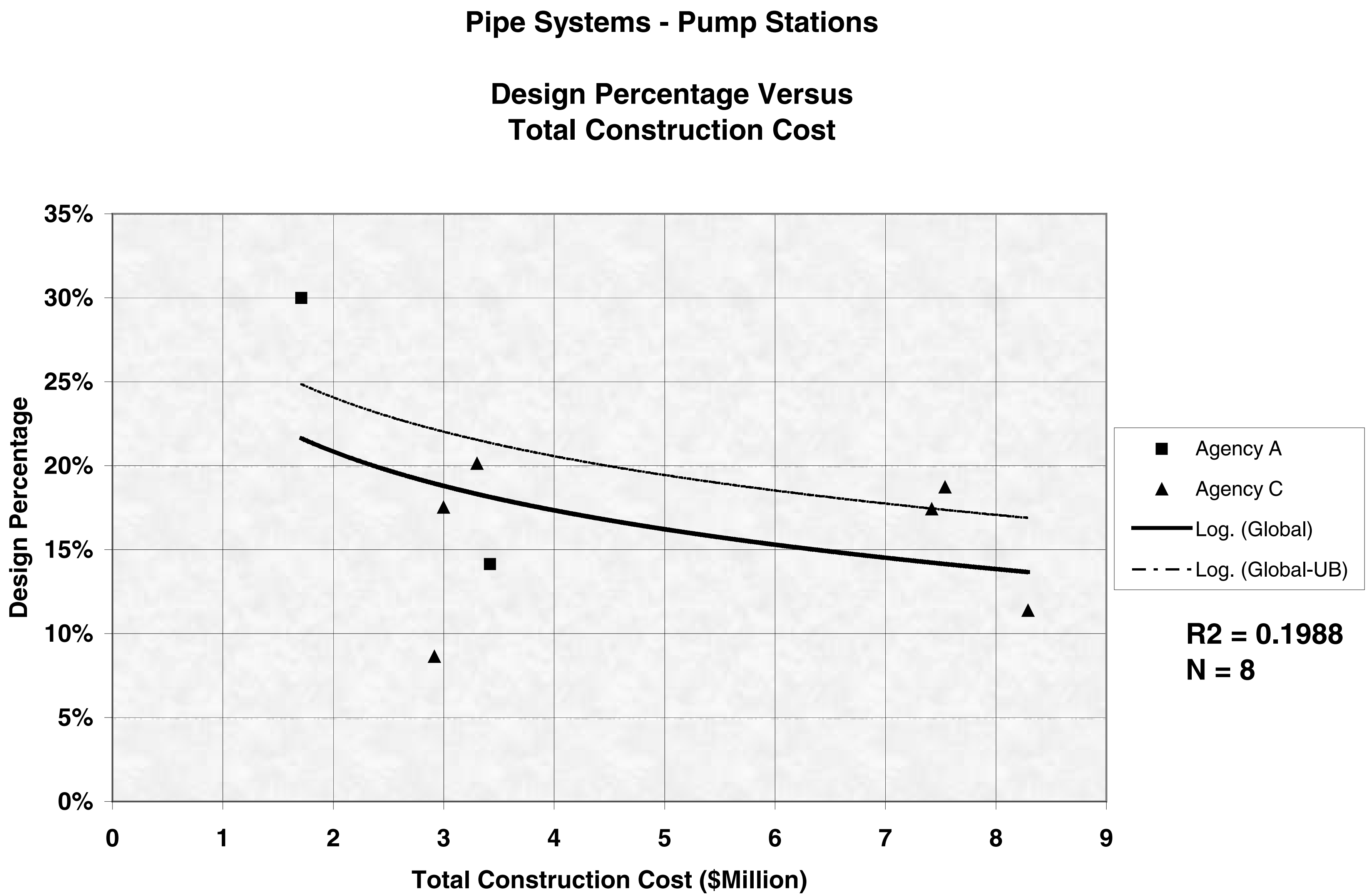
Design Percentage Versus
Total Construction Cost



Pipe Systems - Pressure Systems

Design Percentage Versus
Total Construction Cost




Pipe Systems - Pump Stations
Design Percentage Versus
Total Construction Cost
Design Percentage
35%
30%
25%
20%
15%
10%
5%
0%
0
1
2
3
4
5
6
7
8
9
Total Construction Cost ($Million)
Agency A
Agency C
Log. (Global)
Log. (Global-UB)
R2 = 0.1988
N = 8

Curves Group 2

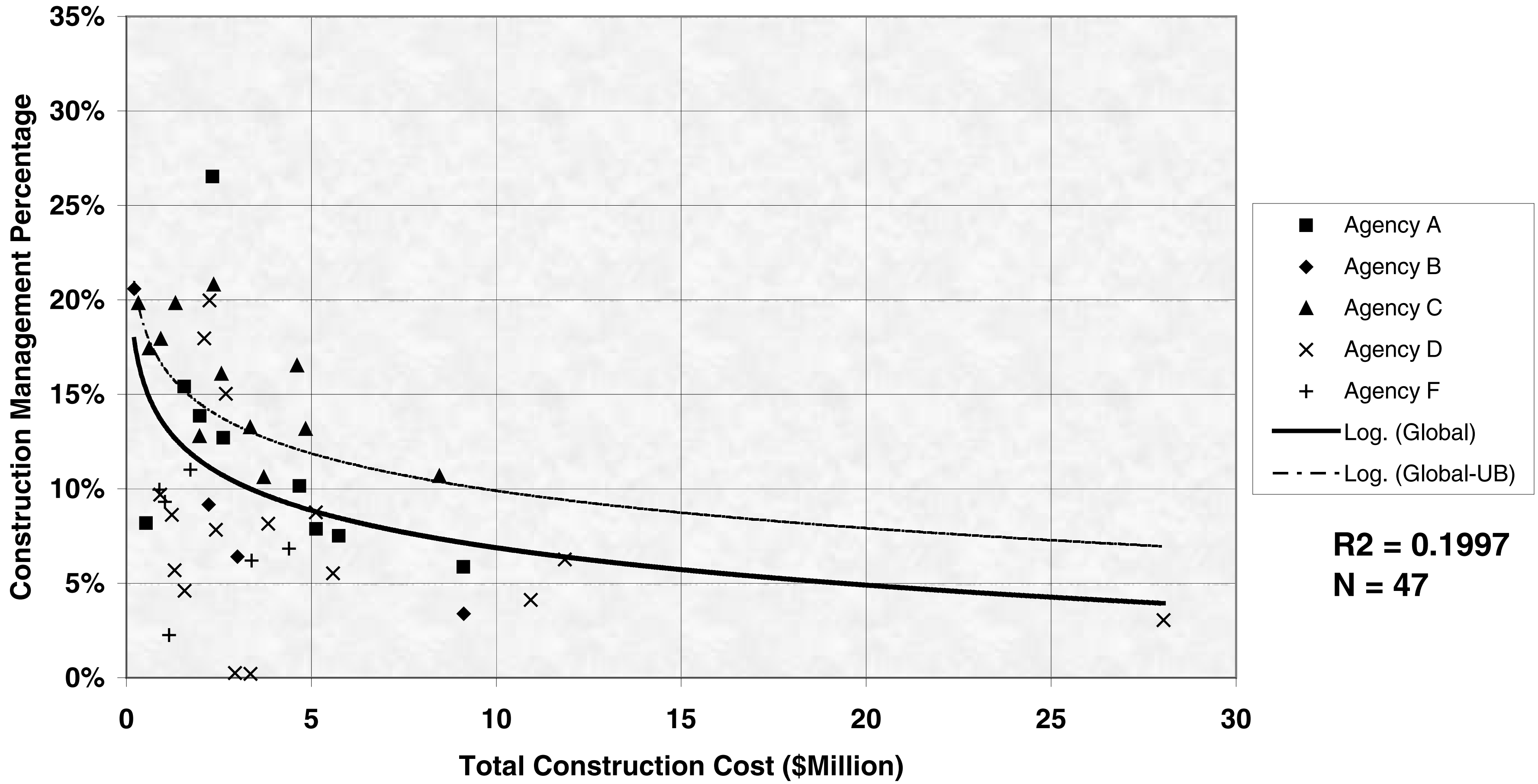
Construction Management Cost / Construction Cost

Versus

Total Construction Cost

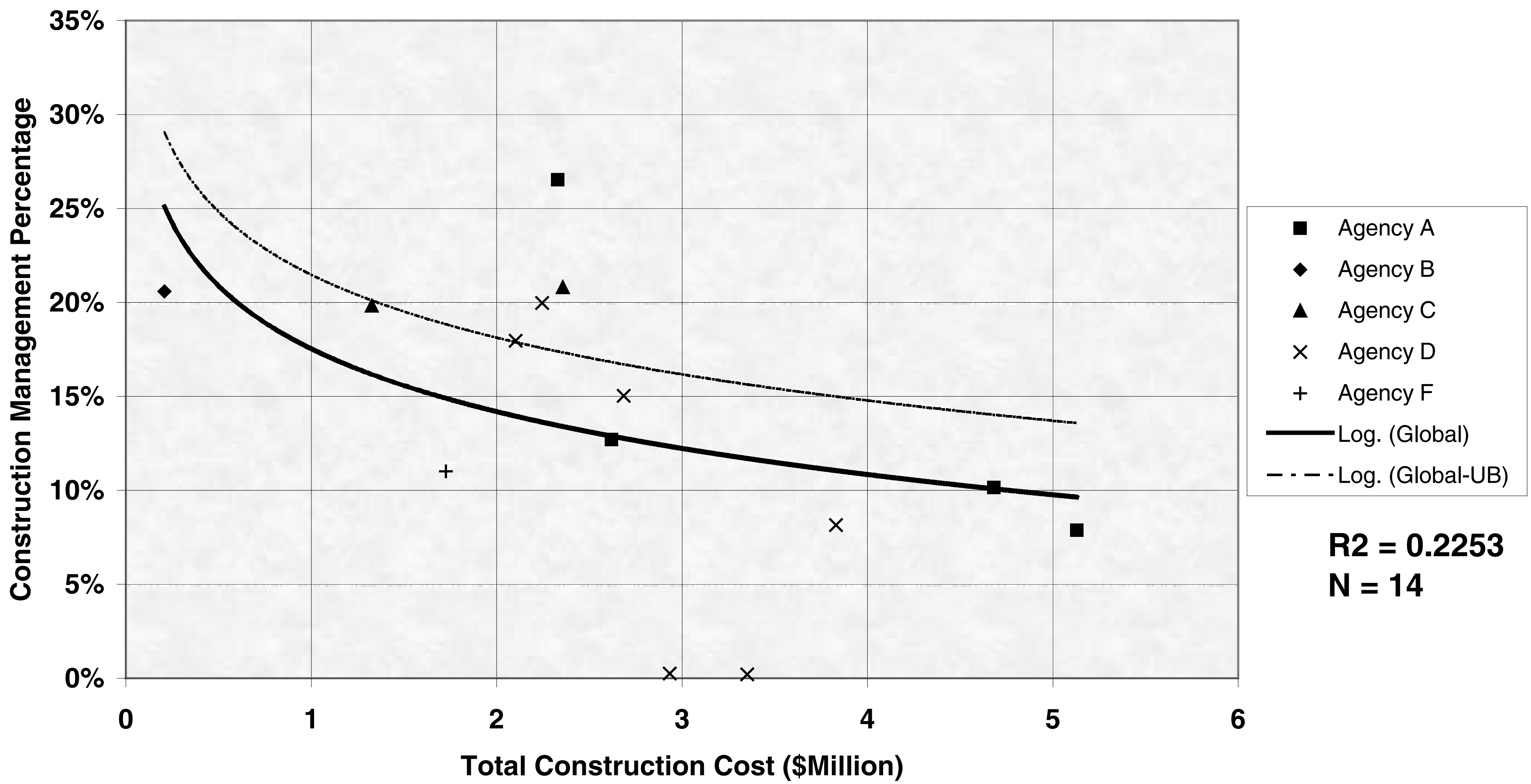
Municipal Facilities - All Classifications

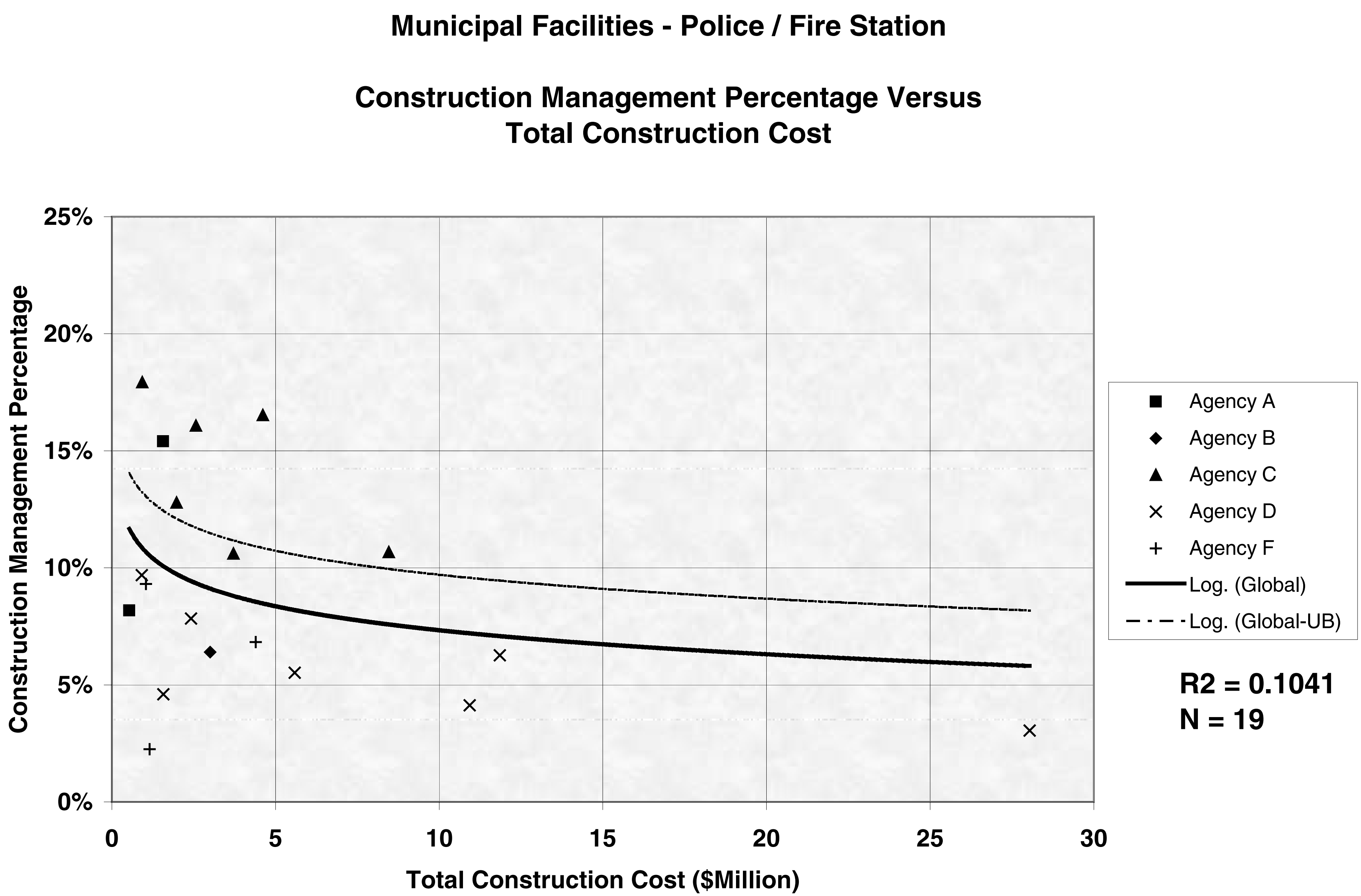
Construction Management Percentage Versus Total Construction Cost



Municipal Facilities - Libraries

Construction Management Percentage Versus Total Construction Cost

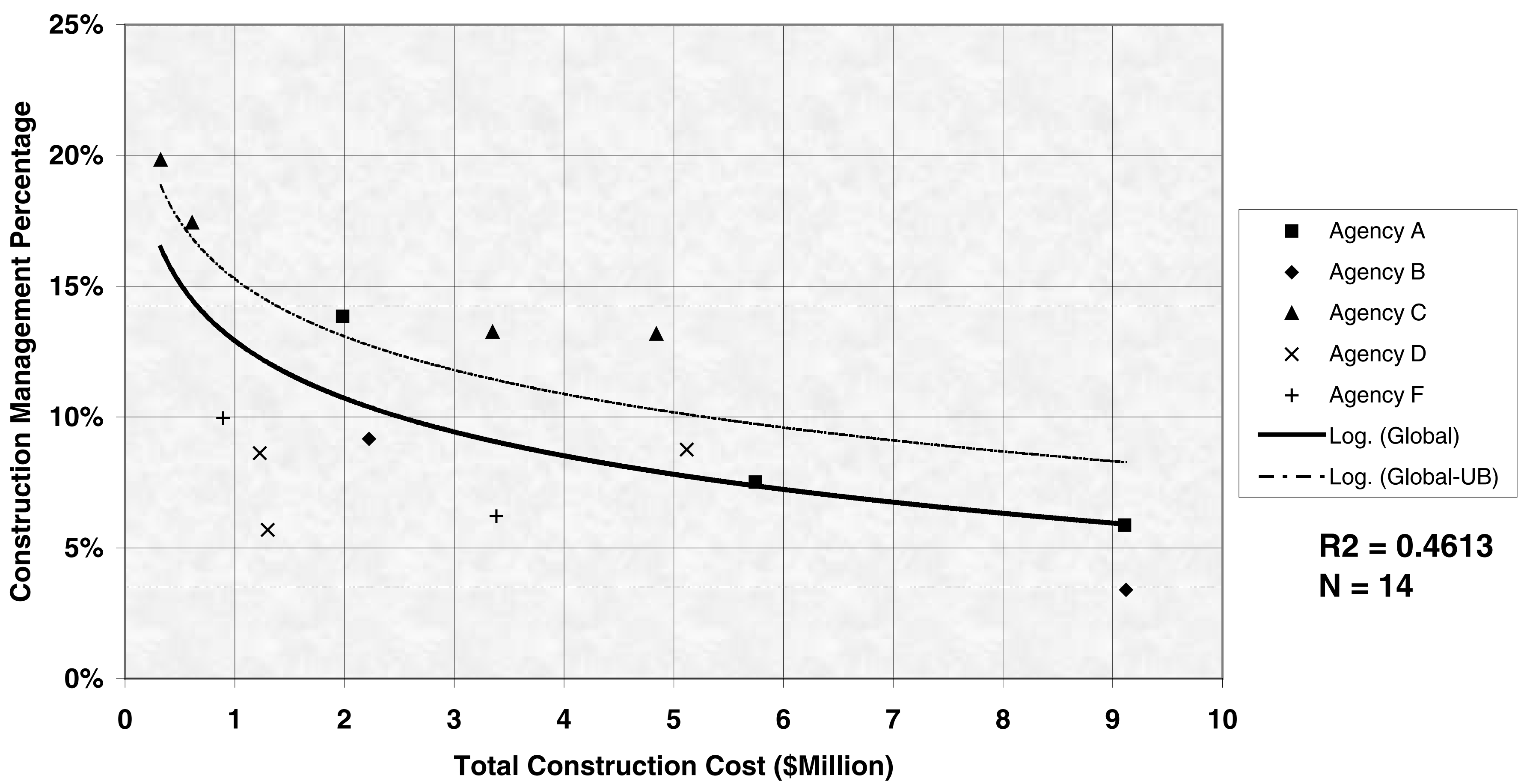




Municipal Facilities - Police / Fire Station
Construction Management Percentage Versus
Total Construction Cost
Construction Management Percentage
25%
20%
15%
10%
5%
0%
0
5
10
15
20
25
30
Total Construction Cost ($Million)
Agency A
Agency B
Agency C
Agency D
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.1041
N = 19

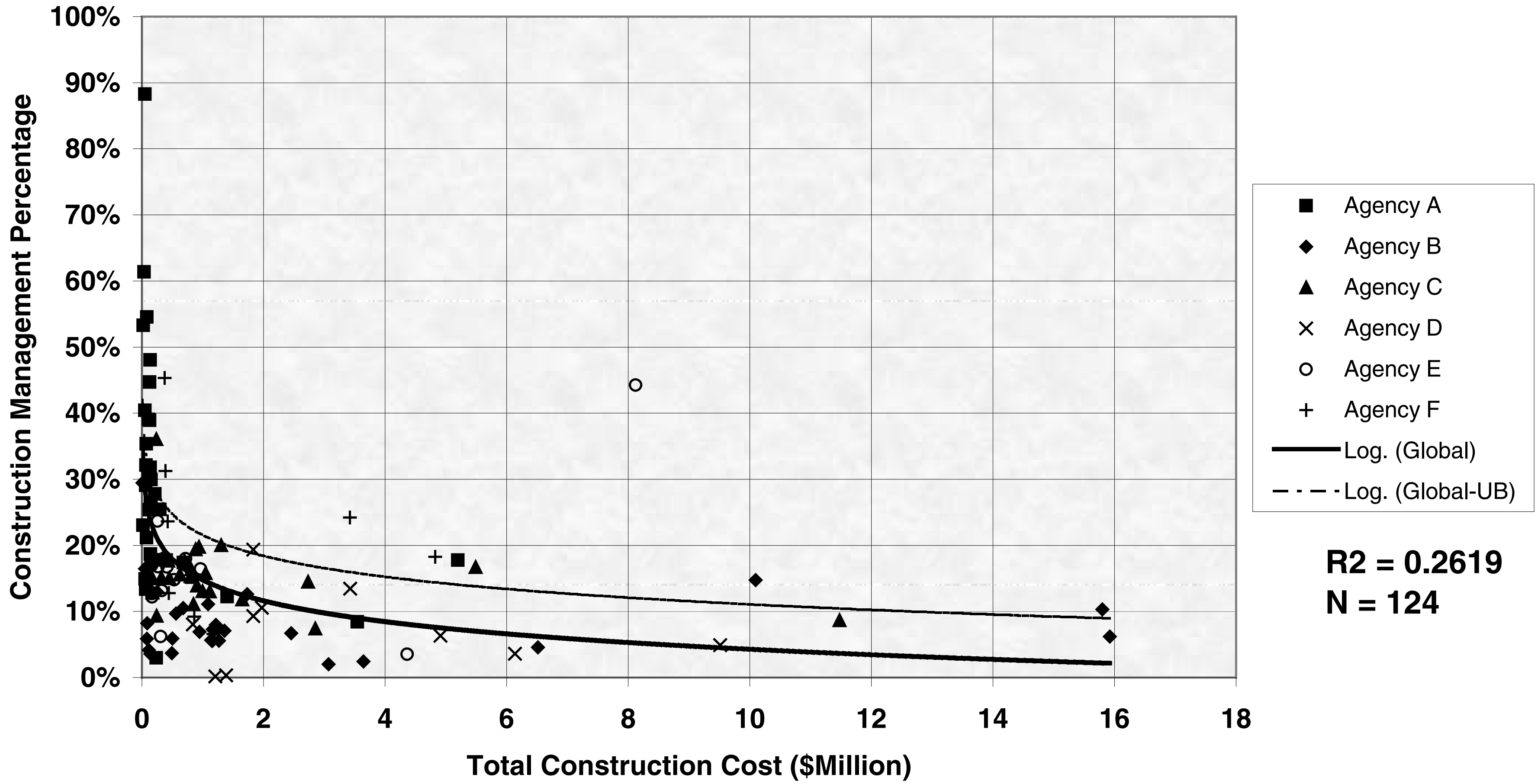
Municipal Facilities - Community Bldg./Rec. Center/CC/Gym

Construction Management Percentage Versus Total Construction Cost



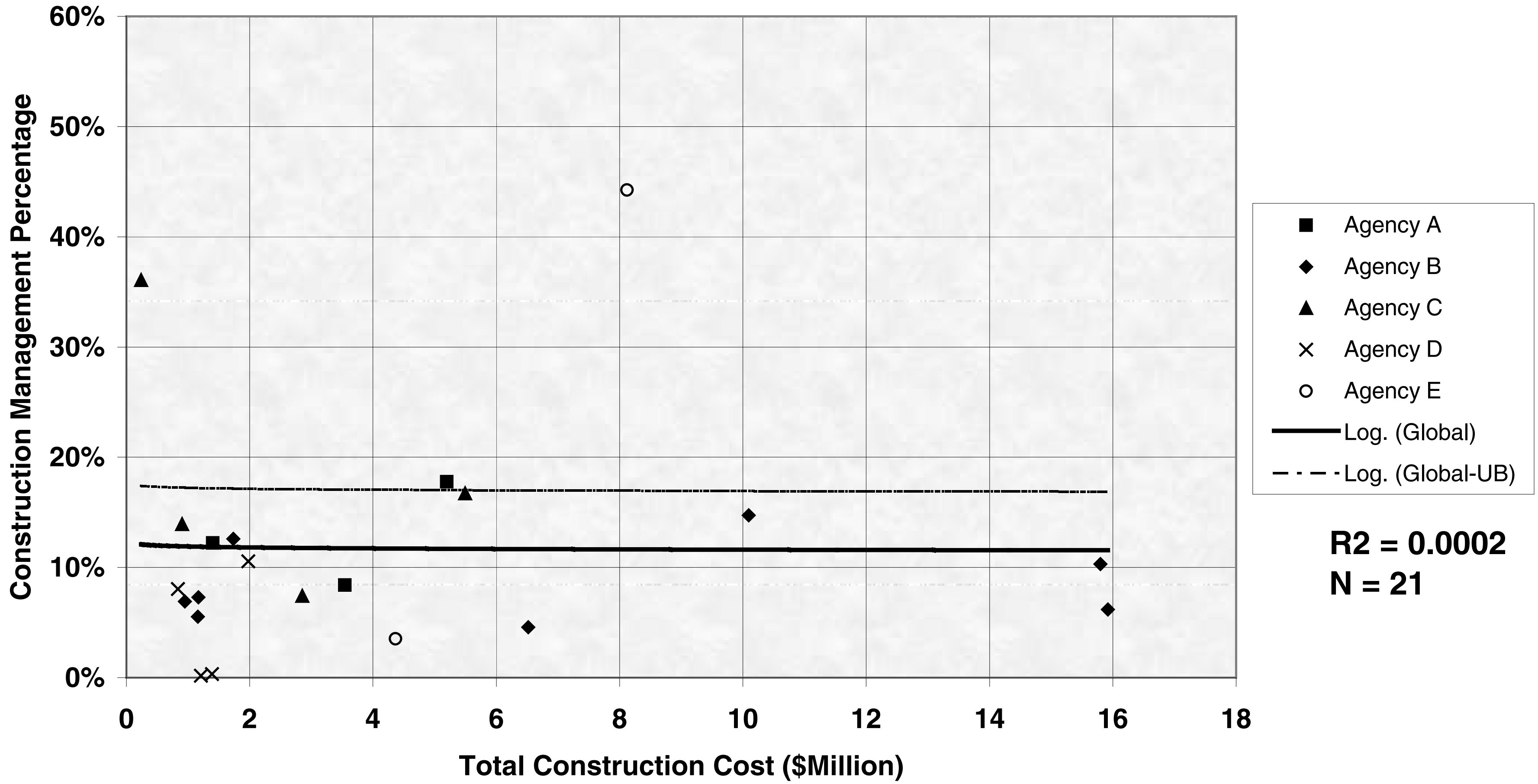
Streets - All Classifications

Construction Management Percentage Versus Total Construction Cost



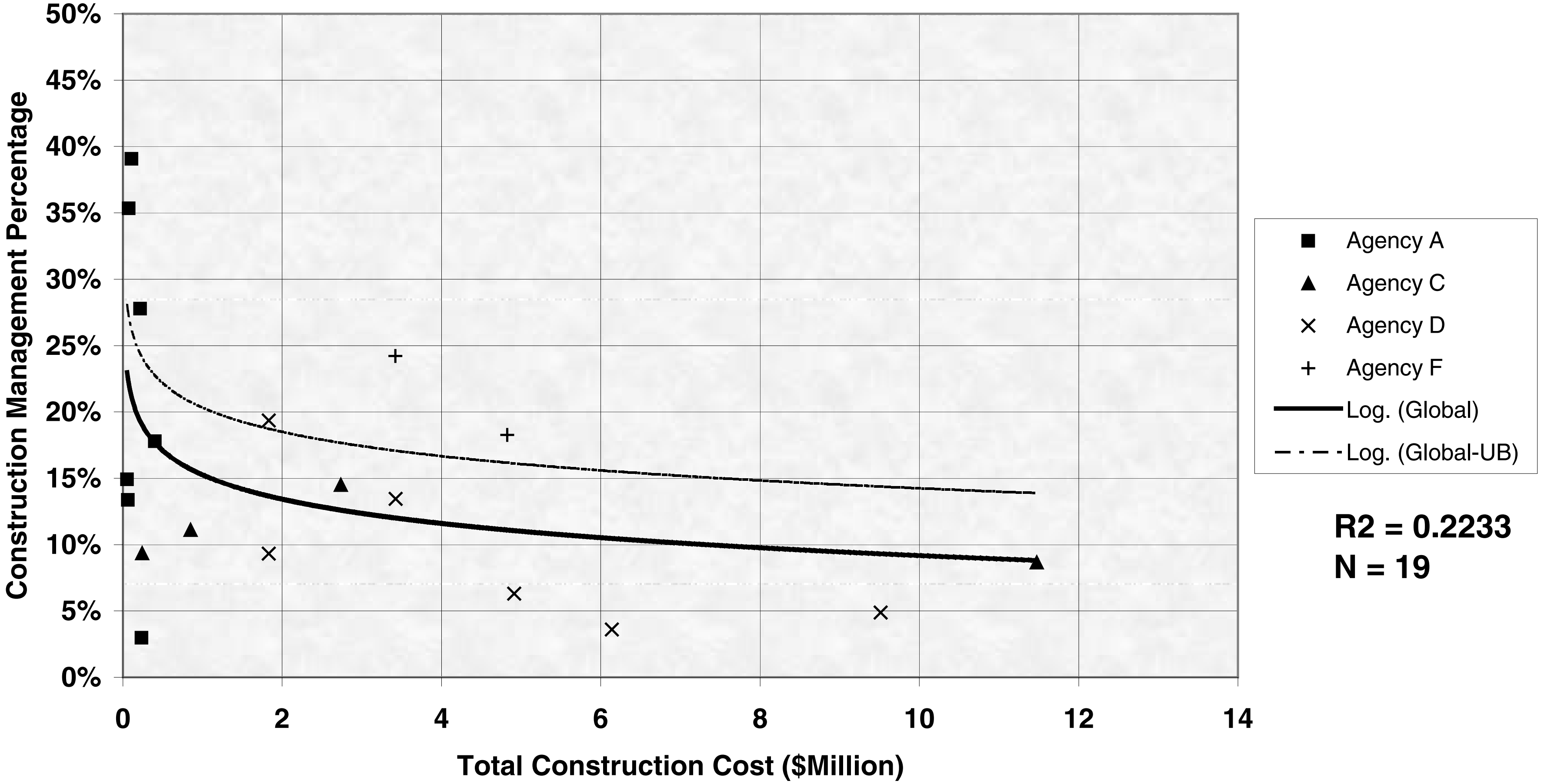
Streets - Widening / New / Grade Separation

Construction Management Percentage Versus Total Construction Cost



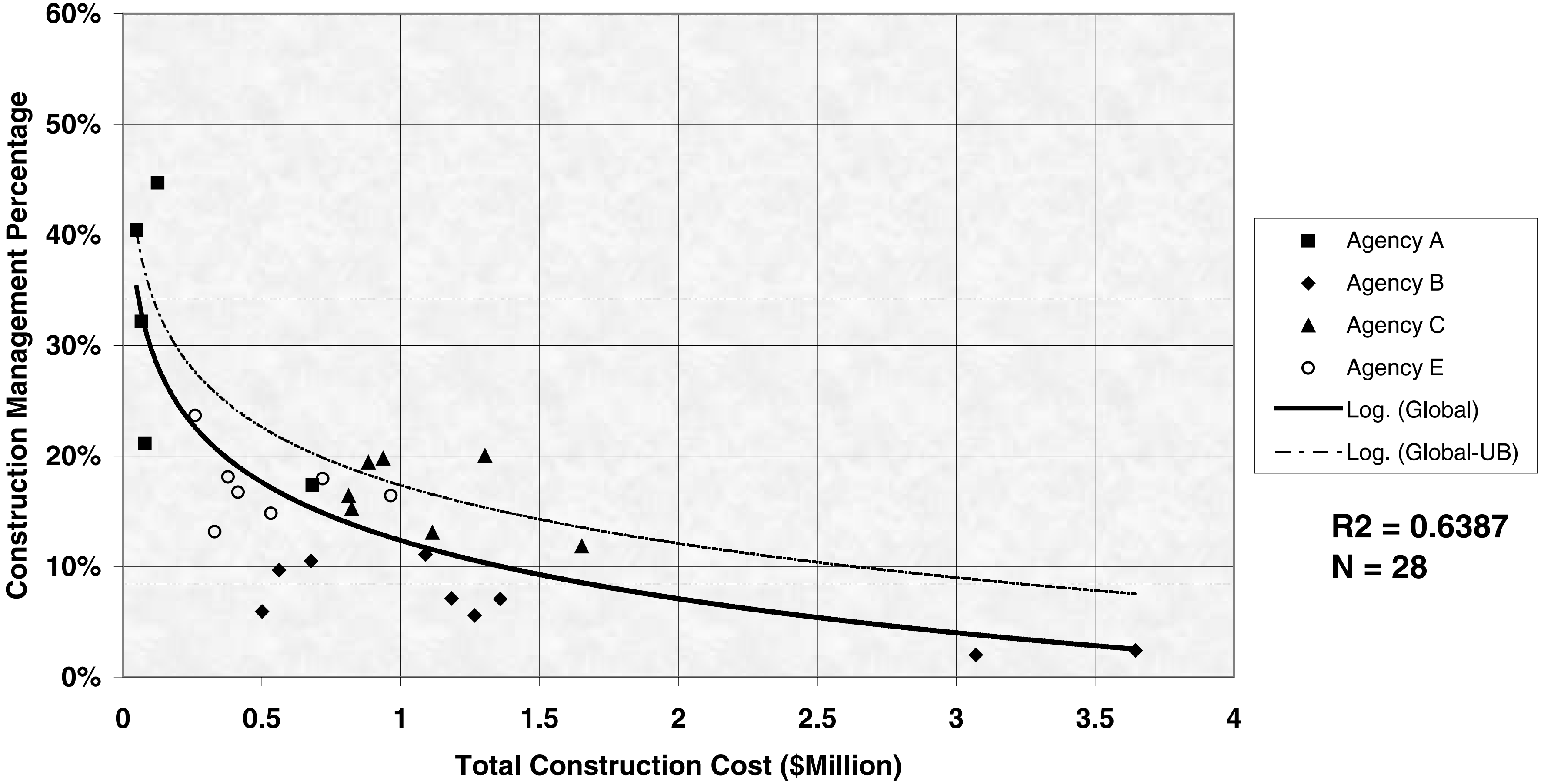
Streets - Bridges (Retrofit / Seismic)

Construction Management Percentage Versus Total Construction Cost



Streets - Renovation / Resurfacing

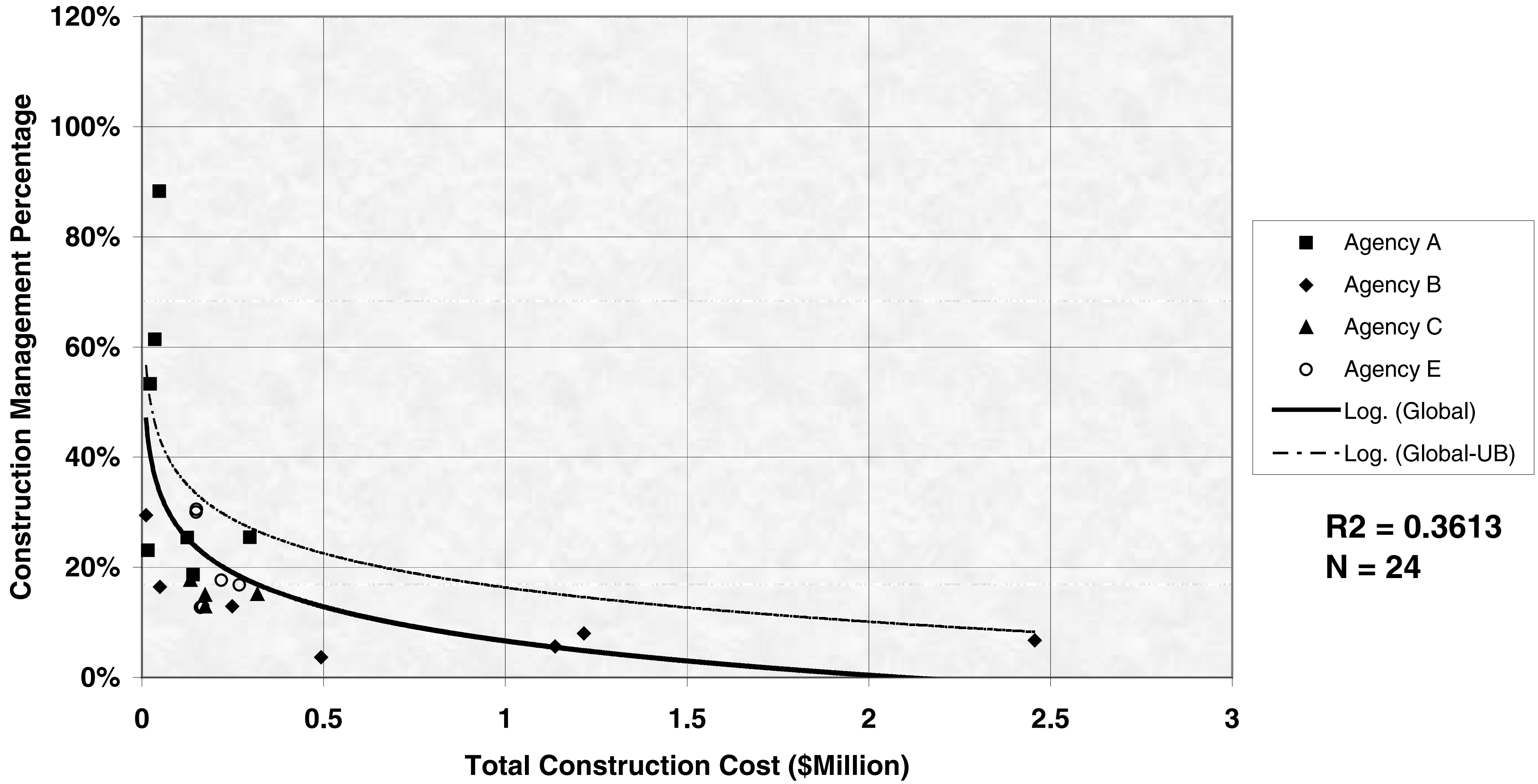
Construction Management Percentage Versus Total Construction Cost



R2 = 0.6387
N = 28

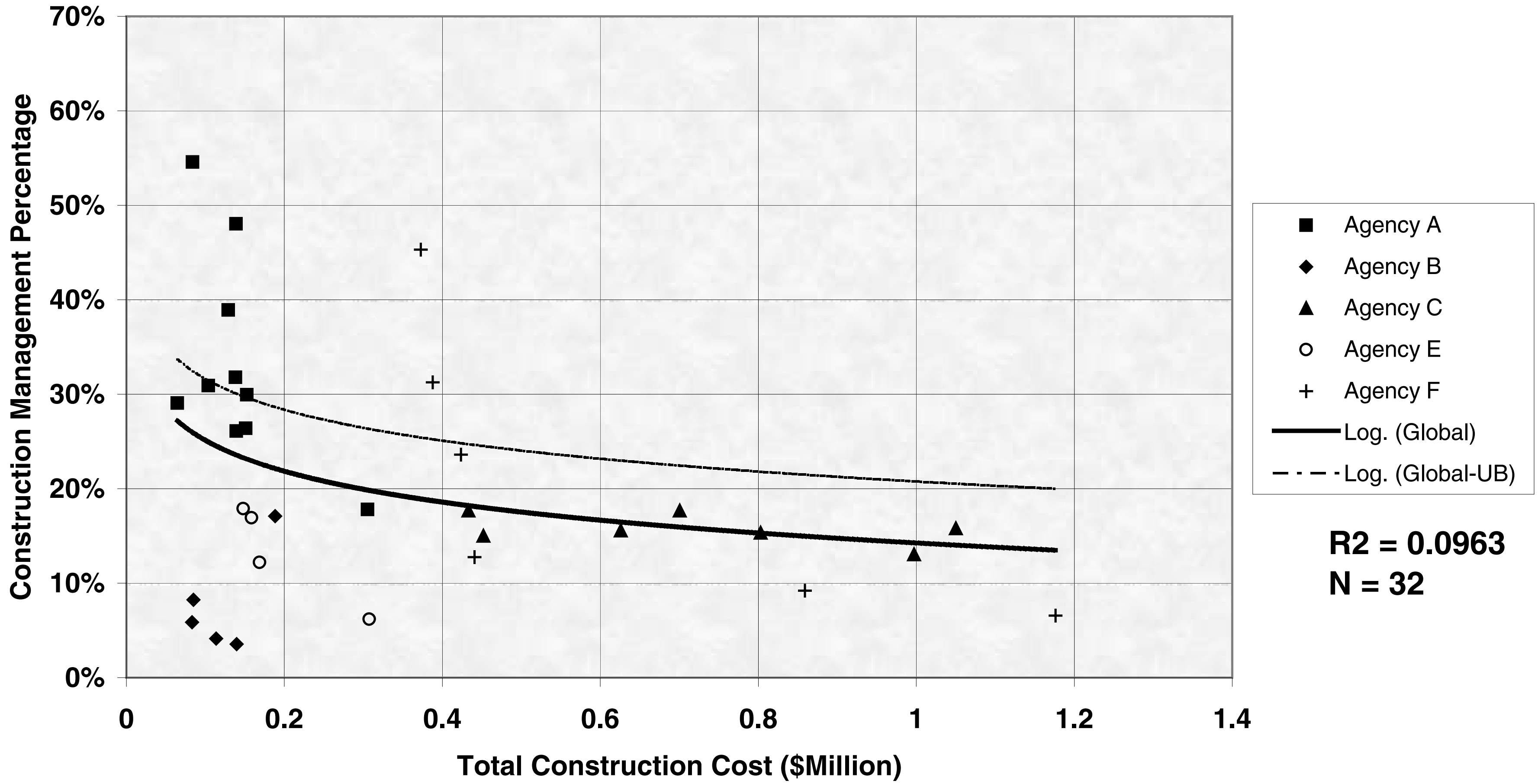
Streets - Bike / Pedestrian / Curb Ramps

Construction Management Percentage Versus Total Construction Cost



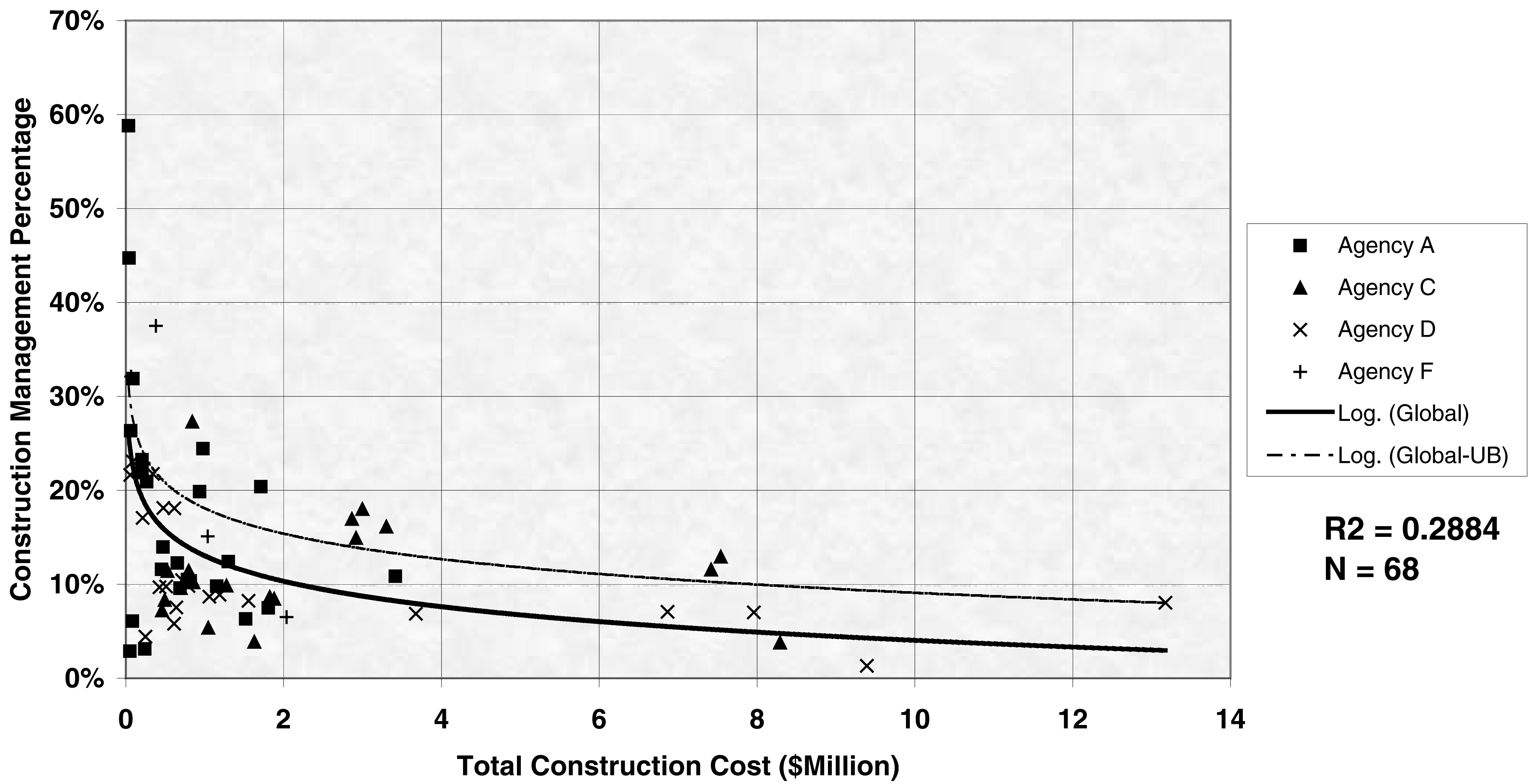
Streets - Signals

Construction Management Percentage Versus Total Construction Cost



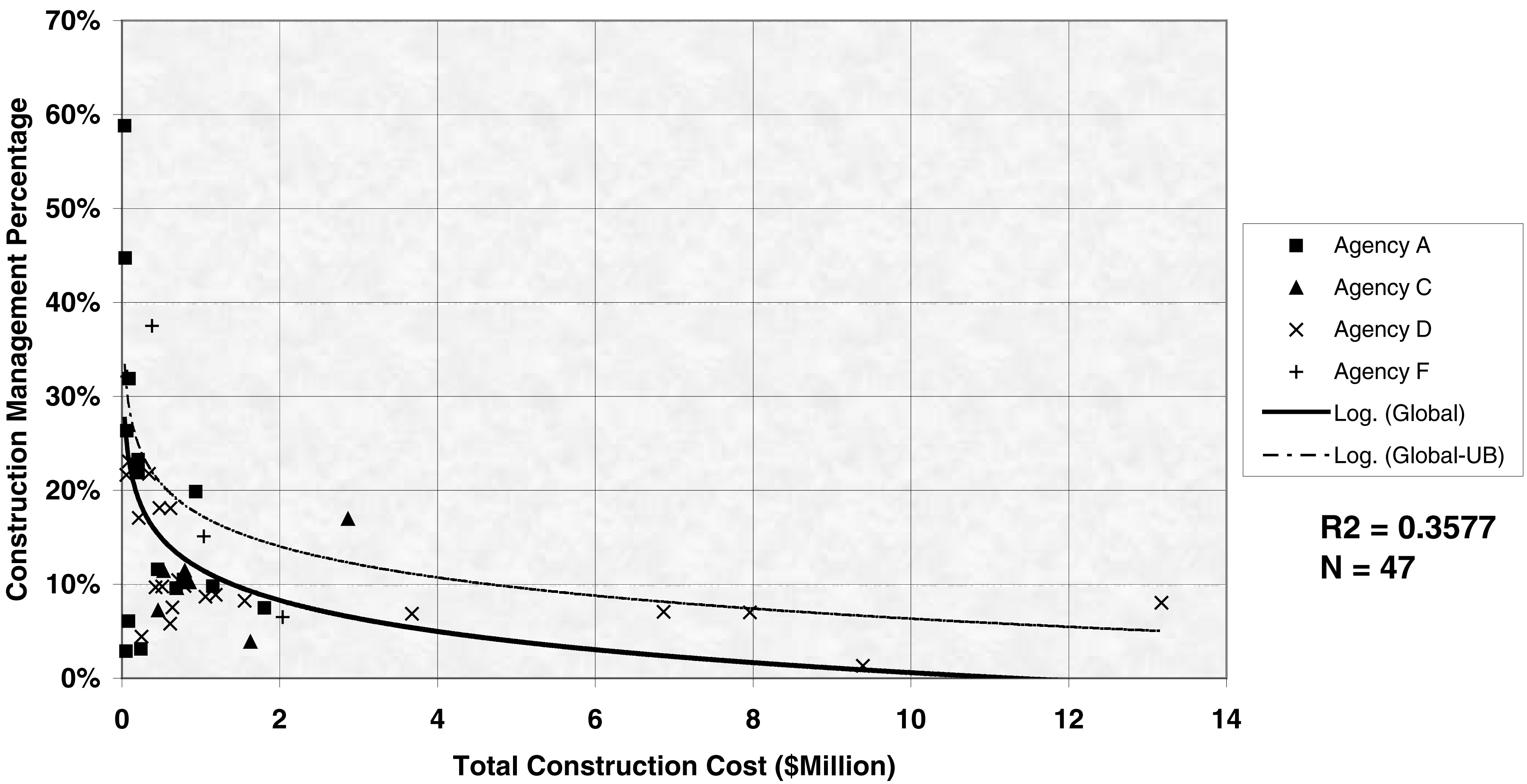
Pipe Systems - All Classifications

Construction Management Percentage Versus Total Construction Cost



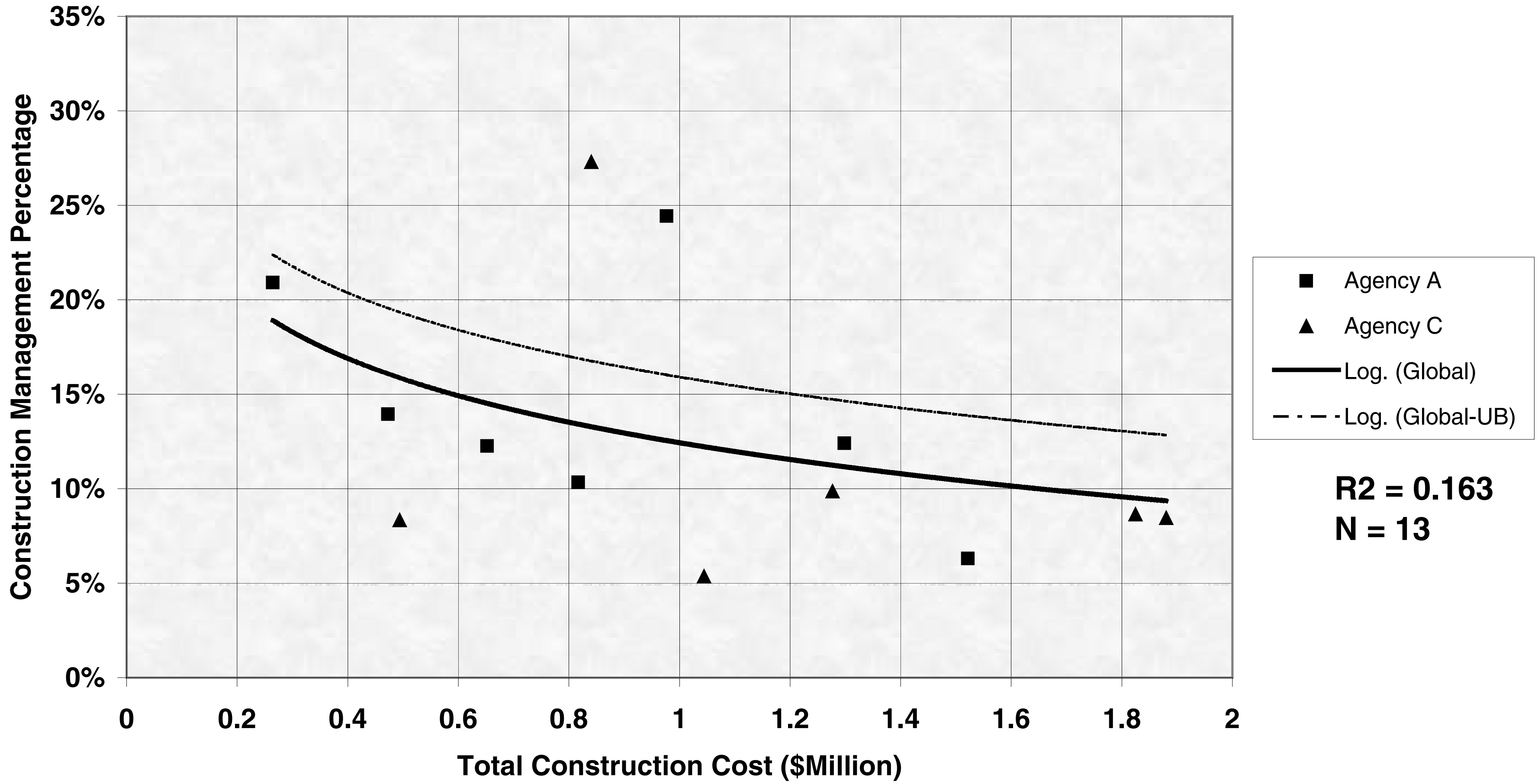
Pipe Systems - Gravity System (Storm Drains, Sewers)

Construction Management Percentage Versus Total Construction Cost



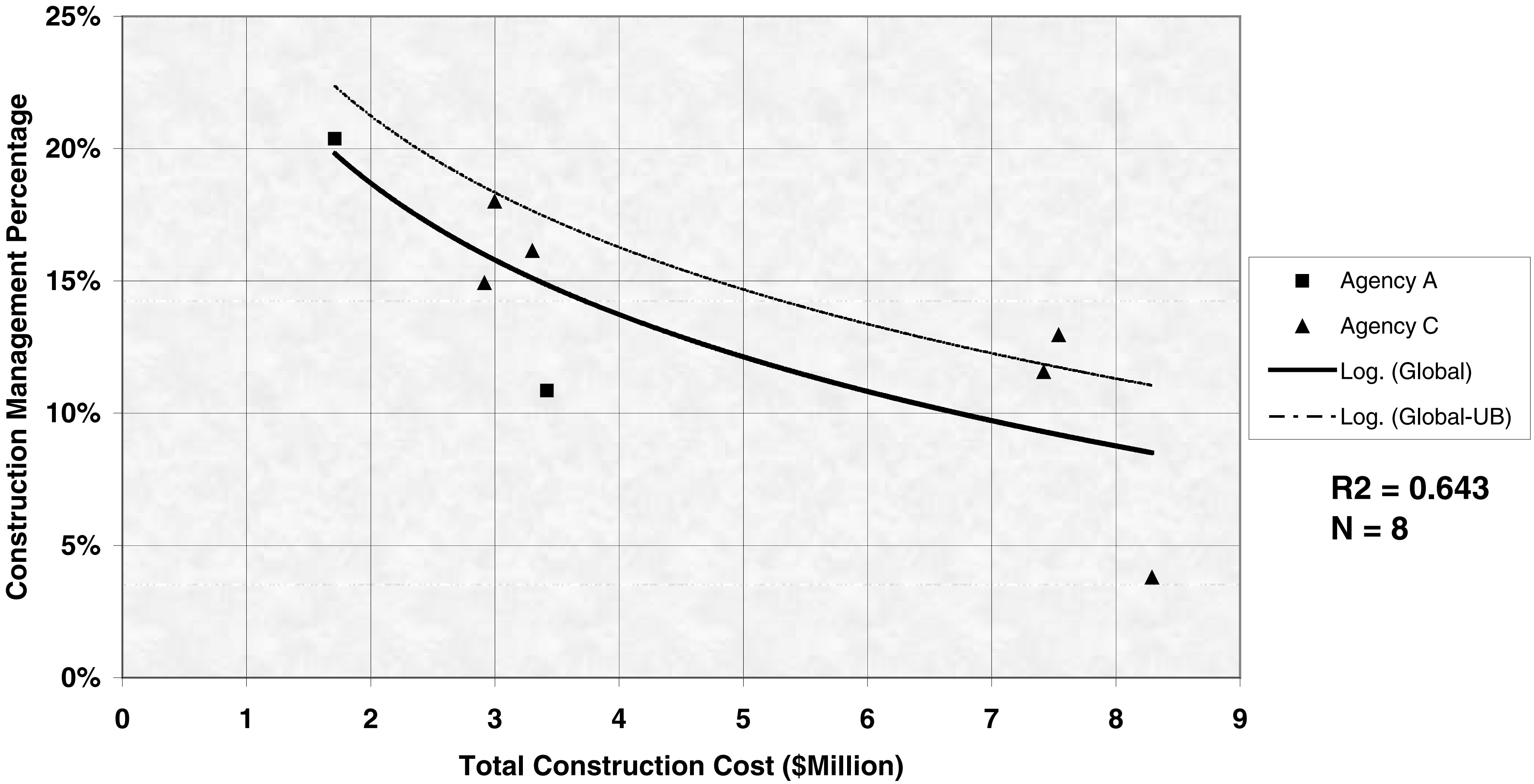
Pipe Systems - Pressure Systems

Construction Management Percentage Versus Total Construction Cost



Pipe Systems - Pump Stations

Construction Management Percentage Versus Total Construction Cost



Curves Group 3

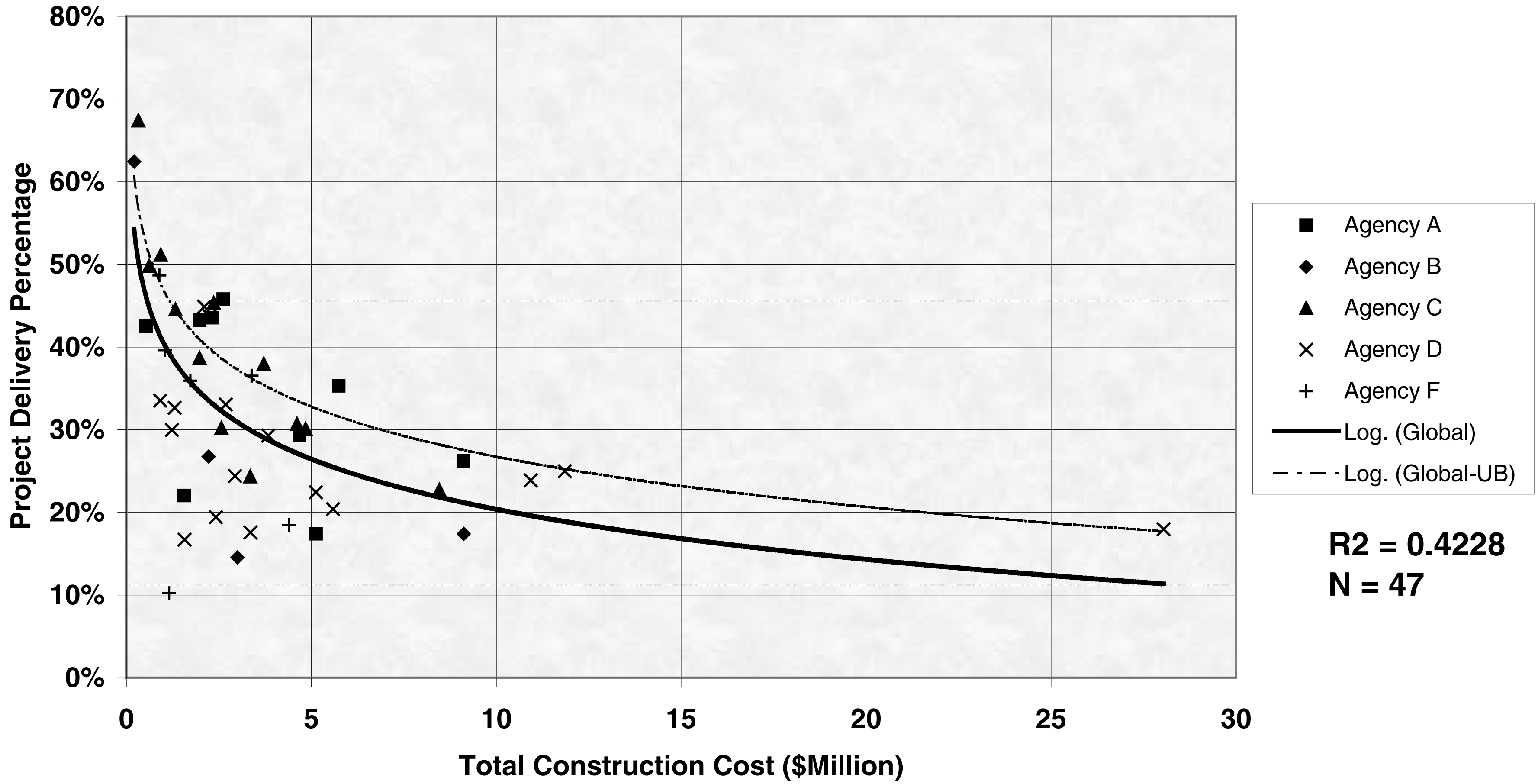
Delivery Cost/ Construction Cost

Versus

Total Construction Cost

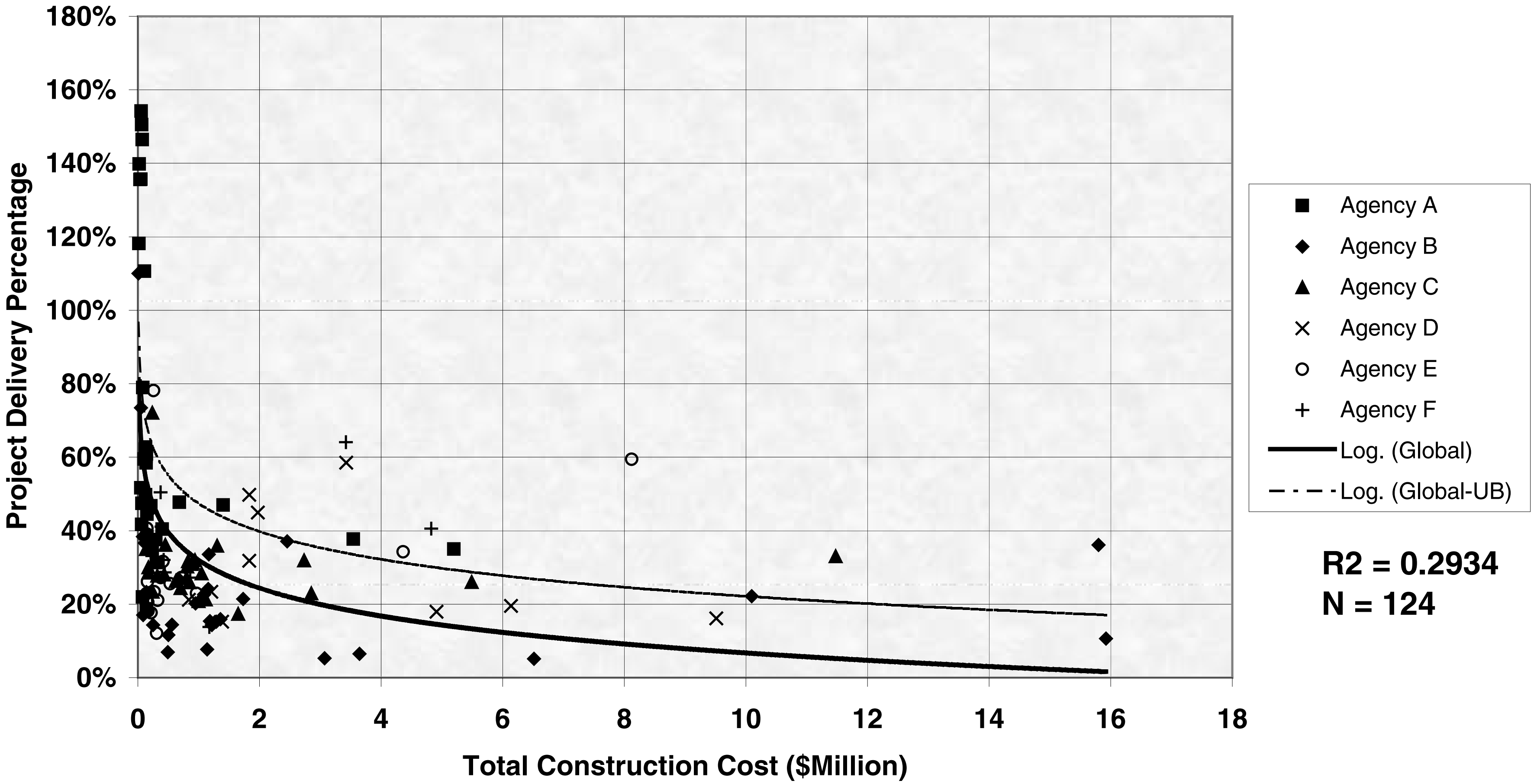
Municipal Facilities - All Classifications

Project Delivery Percentage Versus
Total Construction Cost



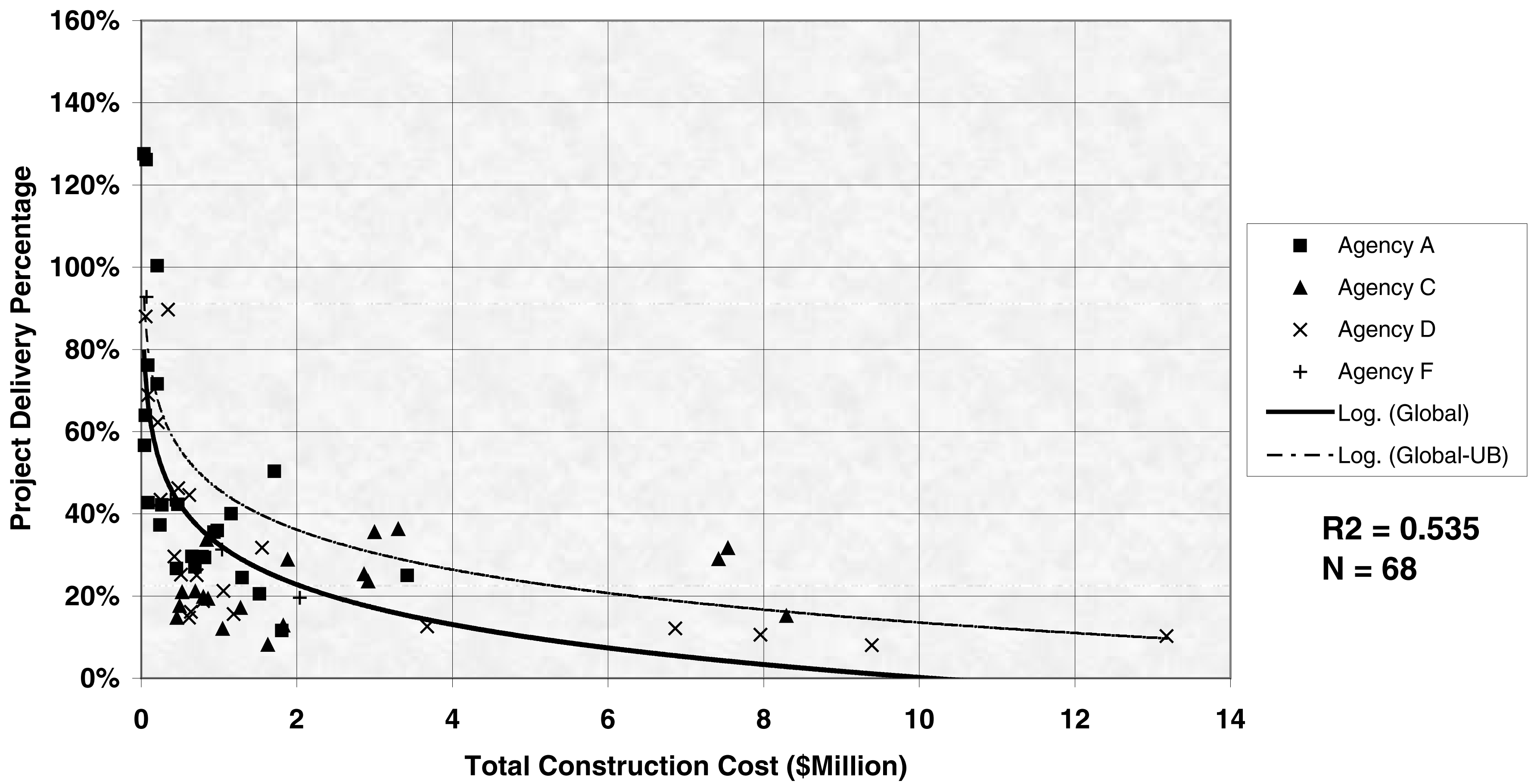
Streets - All Classifications

Project Delivery Percentage Versus Total Construction Cost



Pipe Systems - All Classifications

Project Delivery Percentage Versus Total Construction Cost



Curves Group 4

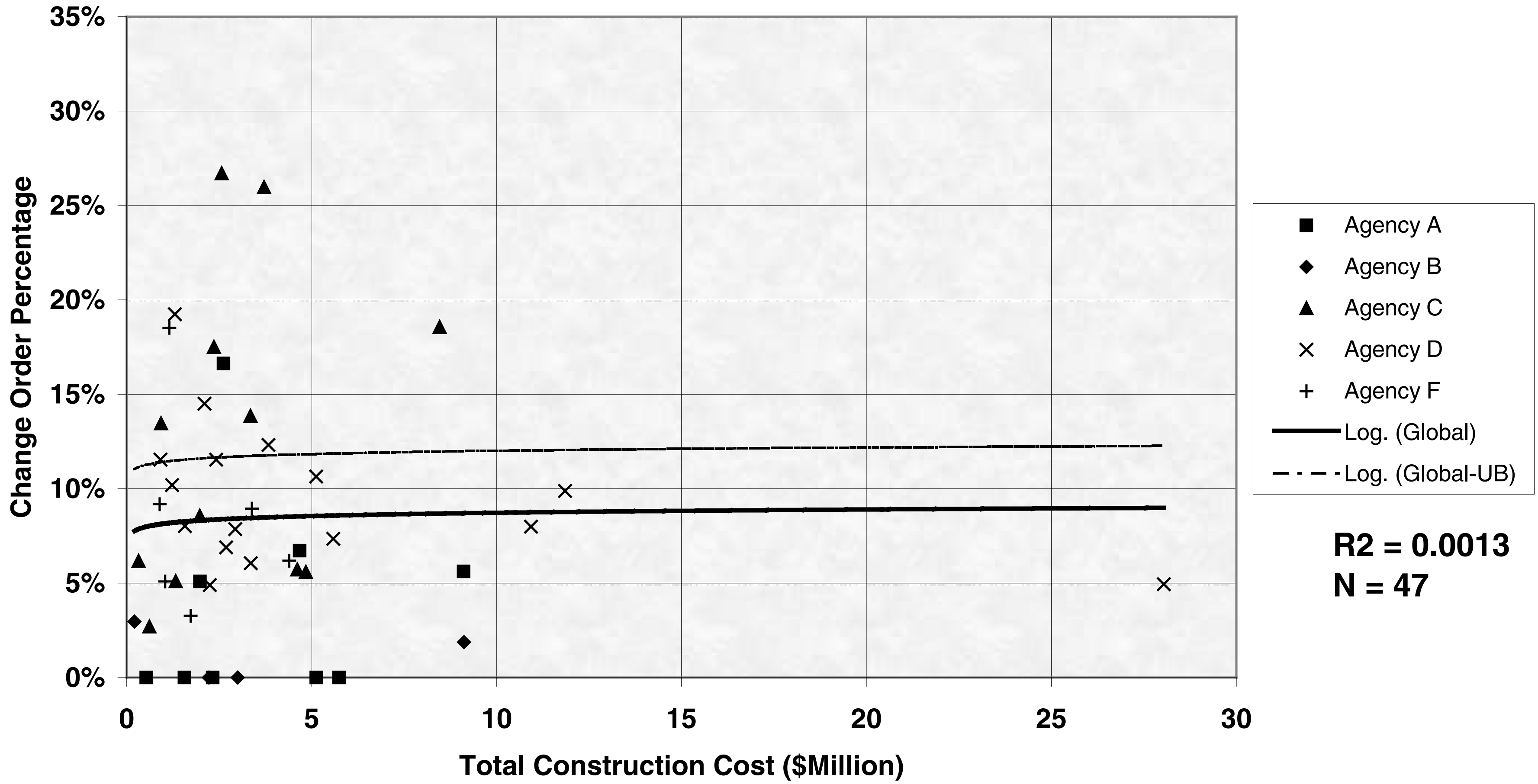
Change Order Cost / Construction Cost

Versus

Total Construction Cost

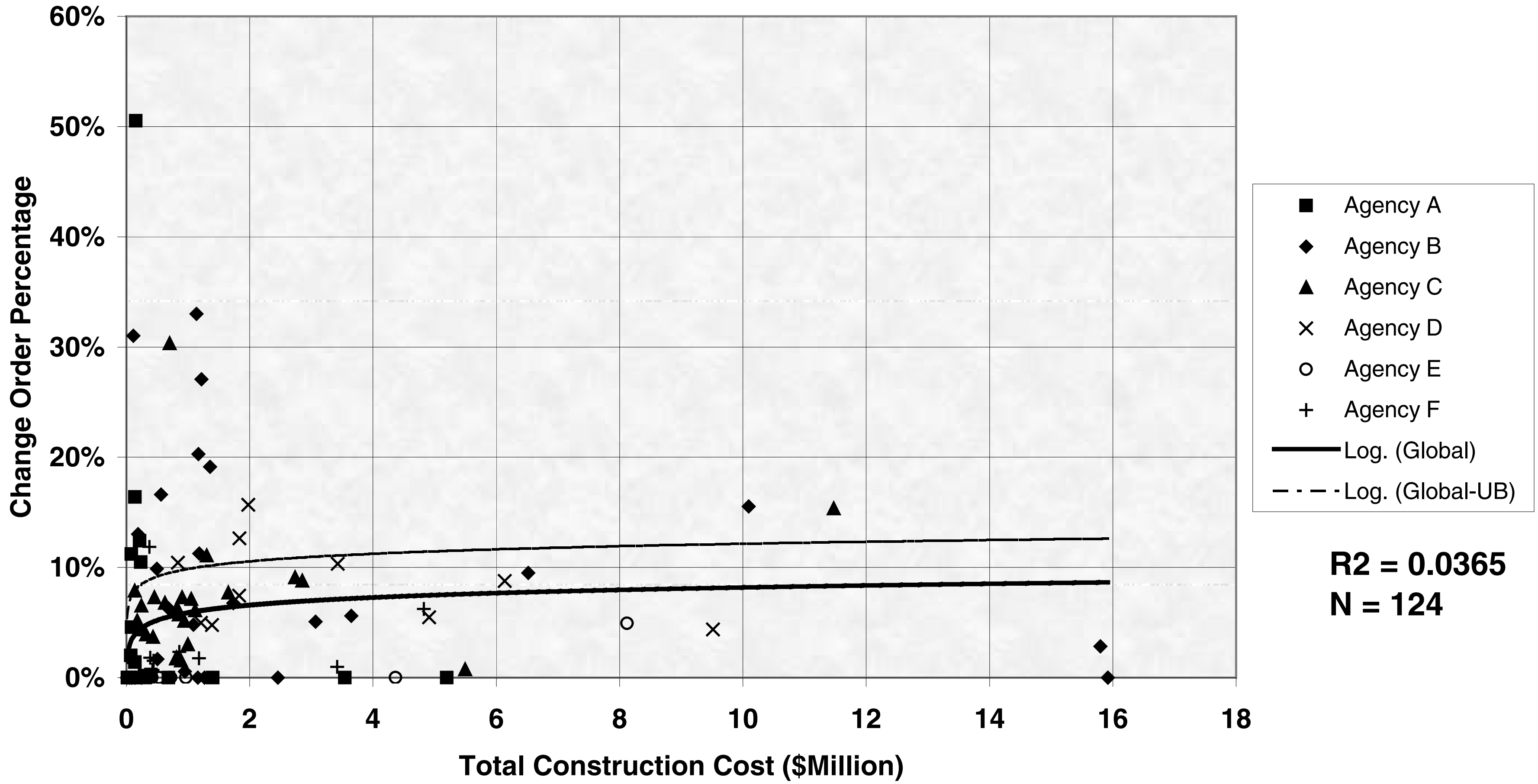
Municipal Facilities - All Classifications

Change Order Percentage Versus Total Construction Cost



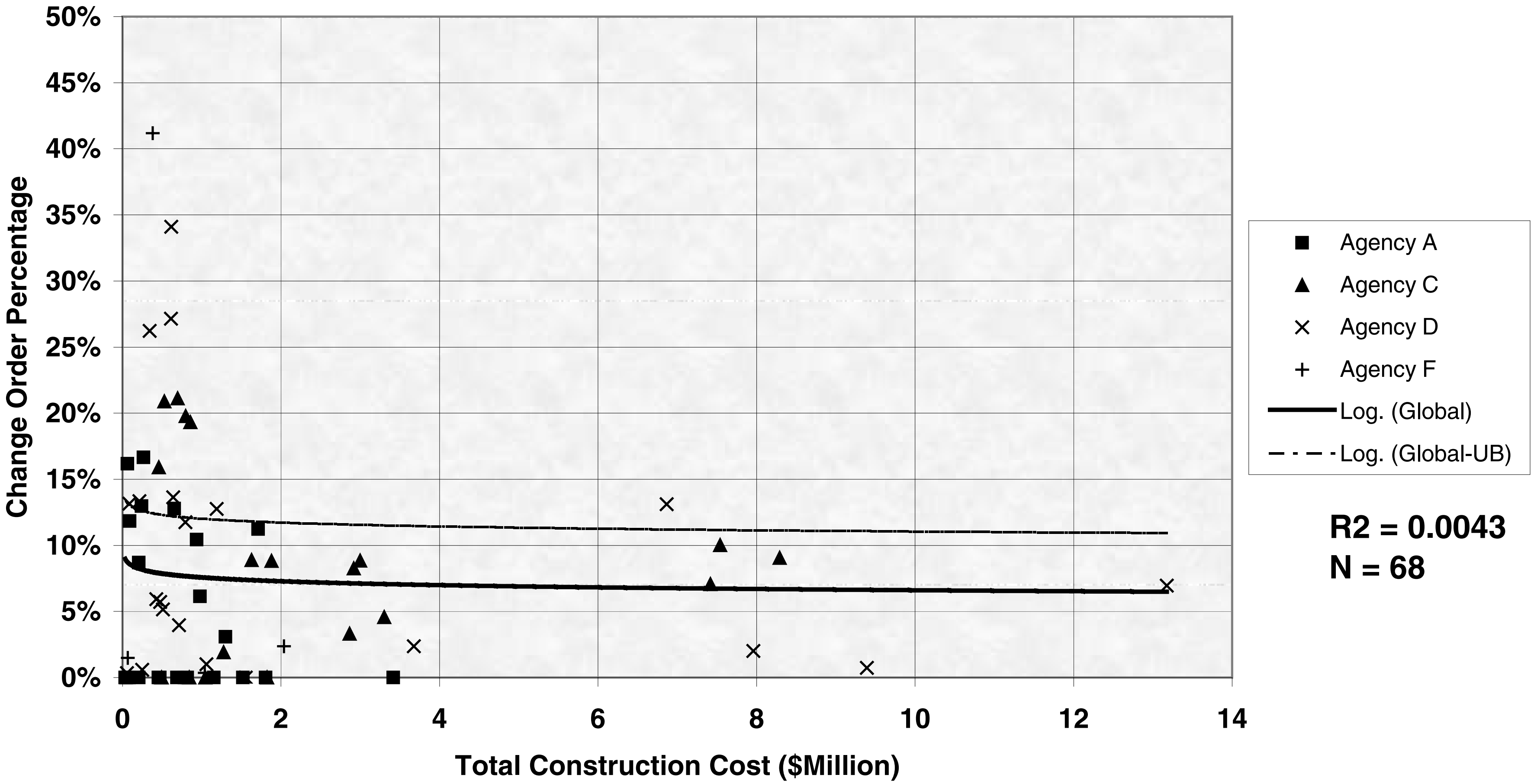
Streets - All Classifications

Change Order Percentage Versus
Total Construction Cost



Pipe Systems - All Classifications

Change Order Percentage Versus Total Construction Cost



R2 = 0.0043
N = 68

Curves Group 5

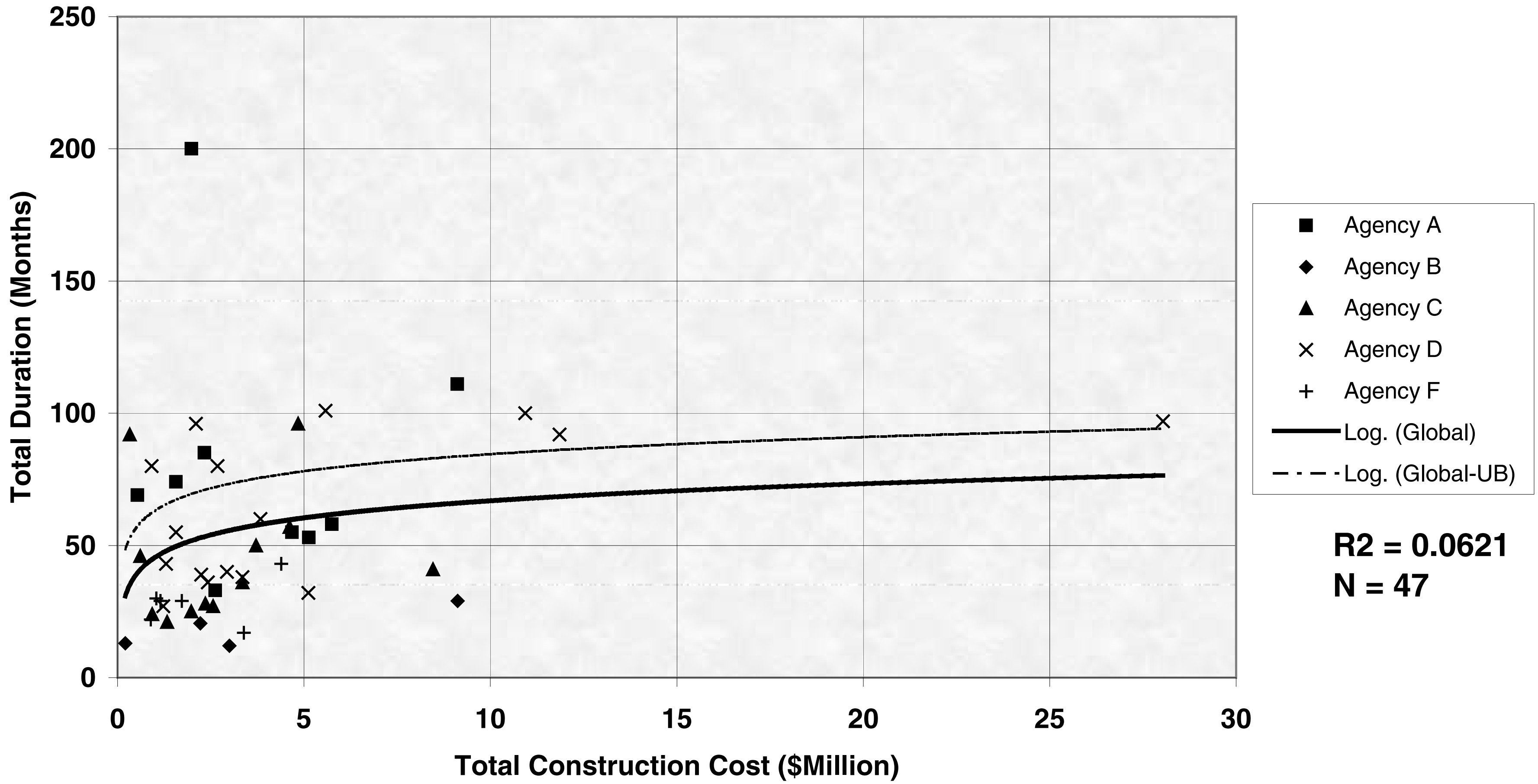
Total Project Duration

Versus

Total Construction Cost

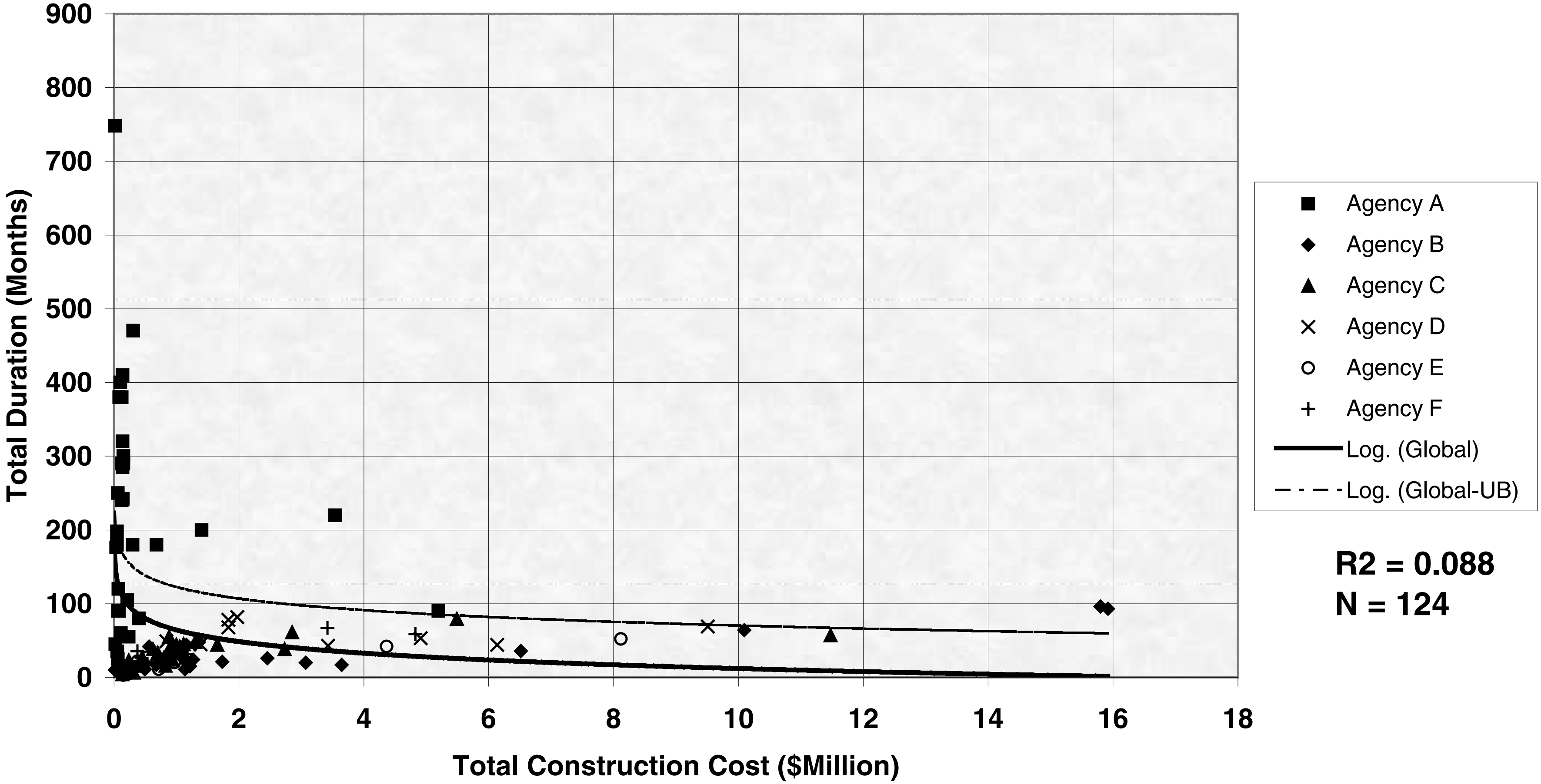
Municipal Facilities - All Classifications

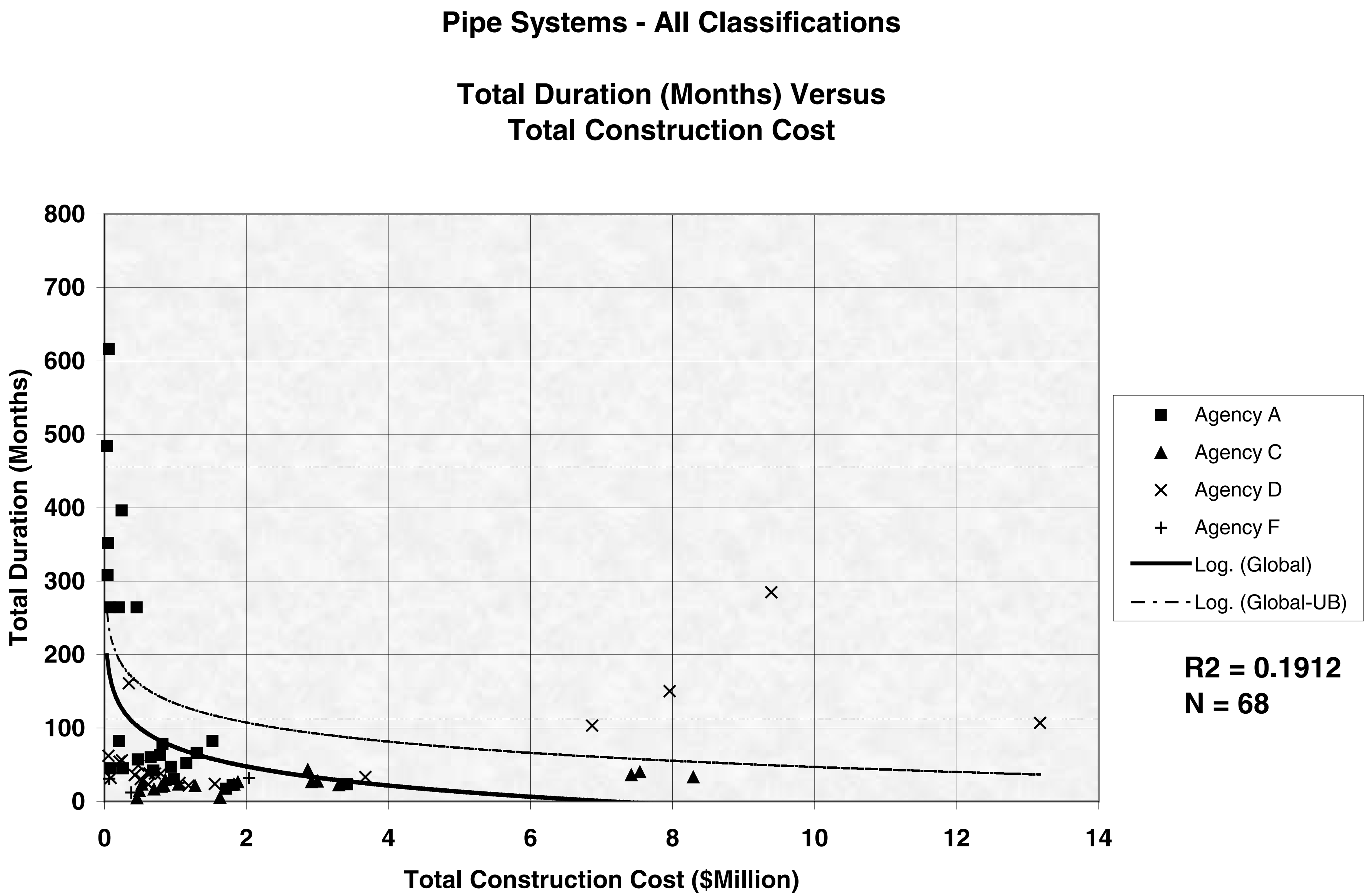
Total Duration (Months) Versus Total Construction Cost



Streets - All Classifications

Total Duration (Months) Versus Total Construction Cost





Pipe Systems - All Classifications
Total Duration (Months) Versus
Total Construction Cost
Total Duration (Months)
800
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
Total Construction Cost ($Million)
Agency A
Agency C
Agency D
Agency F
Log. (Global)
Log. (Global-UB)
R2 = 0.1912
N = 68

Participating Agencies:

- City & County of San Francisco, Department of Public Works/ Bureau of Engineering/ Bureau of Construction Management/ Bureau of Architecture
- City of Sacramento, Department of Public Works
- City of San Jose, Department of Public Works
- City of Los Angeles, Department of Public Works/ Bureau of Engineering
- City of Long Beach, Department of Public Works
- City of San Diego, Engineering & Capital Projects