



THE Event For The Utility Infrastructure Industry

Underground Construction Technology
International Conference & Exhibition

One-Voice for Sewer Condition Assessment Data

Dr. Phil Lewis, Dr. Yongwei Shan, Hossein Khaleghian
Oklahoma State University



Introduction

- This research is a collaborative project between the National Association of Sewer Service Companies (NASSCO) and Oklahoma State University (OSU).
- The goal is to develop a unified national inventory of underground sewer condition assessment data.
- The outcomes will allow sewer stakeholders to have access to existing sewer condition data from across the nation to benchmark sewer infrastructure performance.

Background

- Quality data of current condition of sewer pipelines is fundamental for the development of sewer asset management tools and strategies.
- Factors such as age, material, and soil type that have significant effects on pipe condition were determined.
- However, quality issues in sewer inspection data and condition ratings were not addressed.

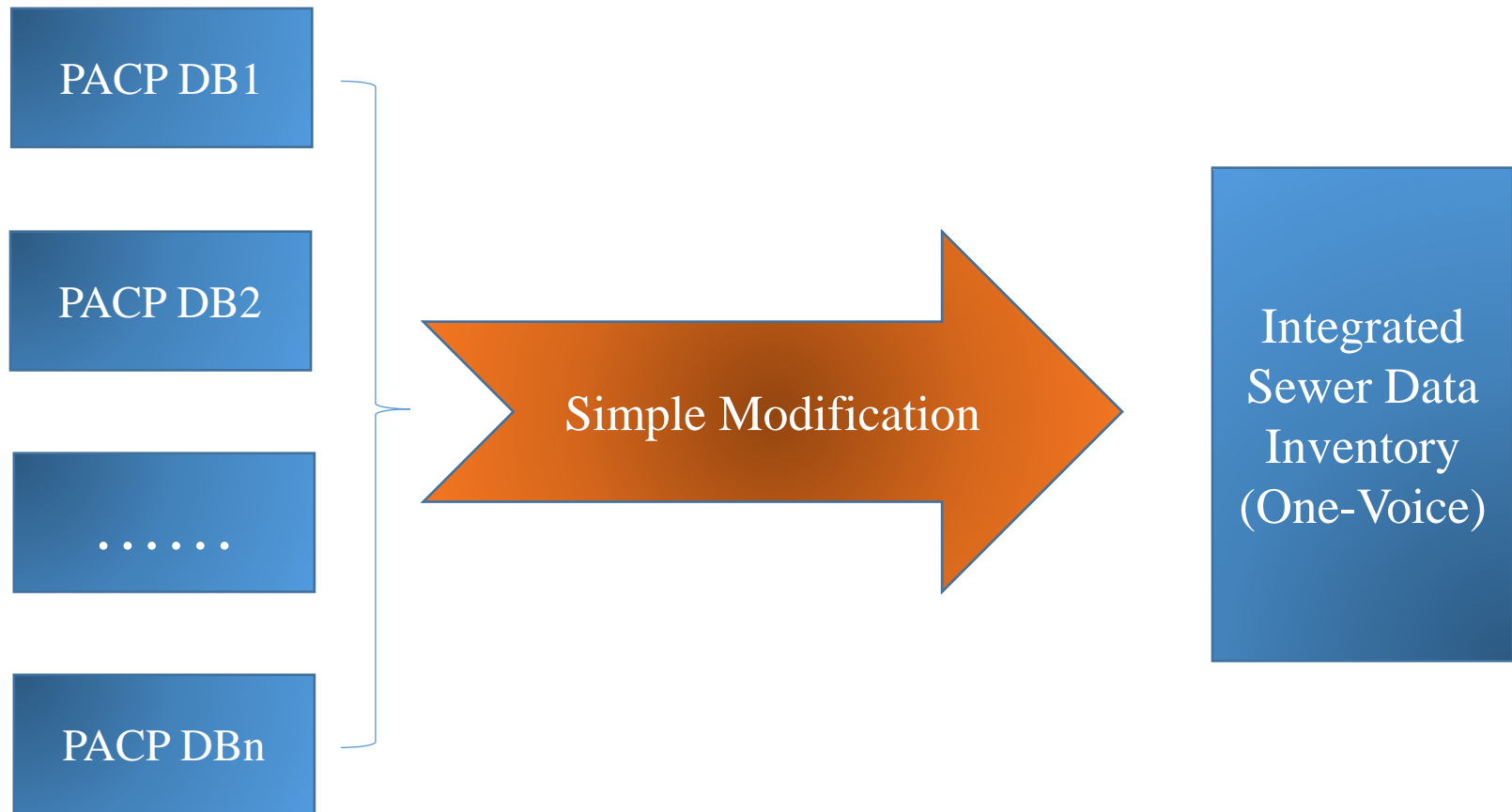
PACP

- In 2002, NASSCO developed the Pipeline Assessment and Certification Program (PACP) as a standard data collection format for Closed-Circuit Television (CCTV) inspections.
- PACP became the industry standard for sewer condition data and it was implemented by more than 200 cities and utility districts.
- The objective of PACP is to evaluate the internal structural and operational condition of sewer pipelines.
- PACP provides a grading system to quantify pipe conditions based on the most severe defects (Quick Rating) or the average severity of grades (Pipe Rating Index).

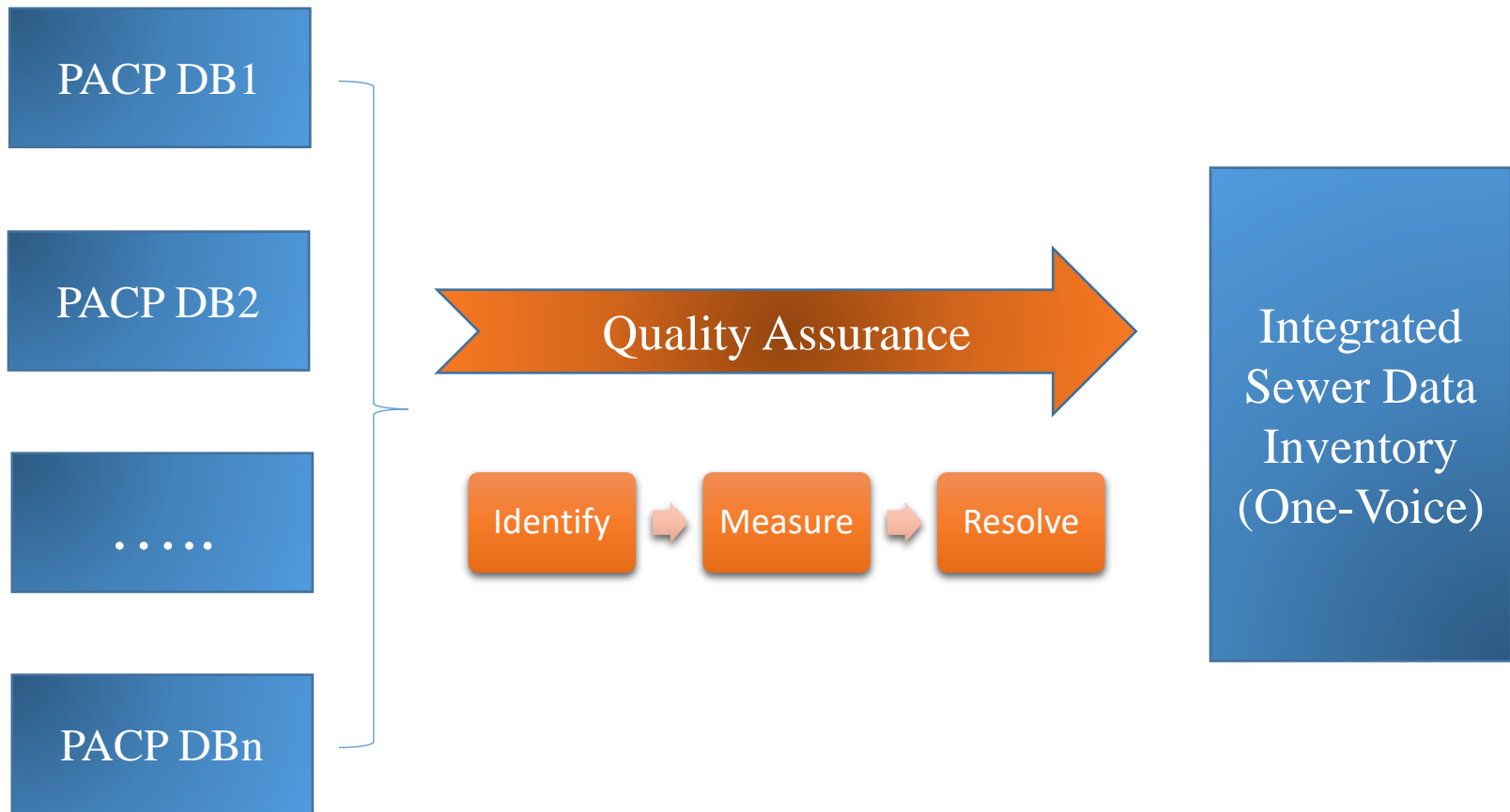
Research Approach

- Collecting PACP Data
- Identifying data quality issues in PACP databases.
- Developing data quality assurance process to address those issues:
 - Data Quality Metrics
 - Data Quality Framework
 - PACP Grading System

Original Project Objectives



Updated Project Objectives









Data Collection

- A confidentiality agreement was drafted to ensure anonymity to data providers.
- Data transfer protocols were developed to ensure security of the data storage.
- To date, six datasets have been collected and two different PACP data collection software programs were evaluated.
- Based on six datasets, the research team identified differences in data management practices among the data providers.







First Database (FW)

- Coding System: PACP 6
- Data Structure: PACP 6
- Inspections: 5232
- Conditions: 84785
- Main Problems:
 - Duplications

Tables		⌵
	Code_Substitutions	
	Conditions	
	Custom_Fields	
	Custom_Labels	
	Inspections	
	LACP_Conditions	











Second Database (SUD)

- Coding System: PACP 6
- Data Structure: Software Preference
- Inspections: 212
- Conditions: 1916
- Main Problems:
 - Duplications
 - Data Structure
 - 121 Input Errors

Tables		
	Info	
	L	
	LI	
	LO	
	Media	
	Media_Path	

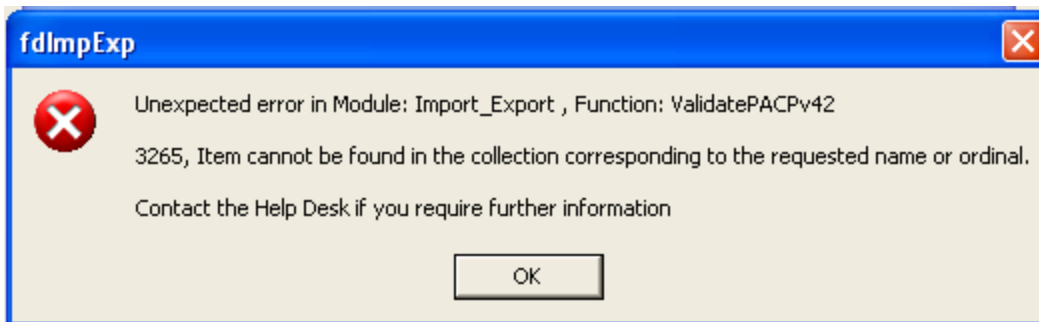
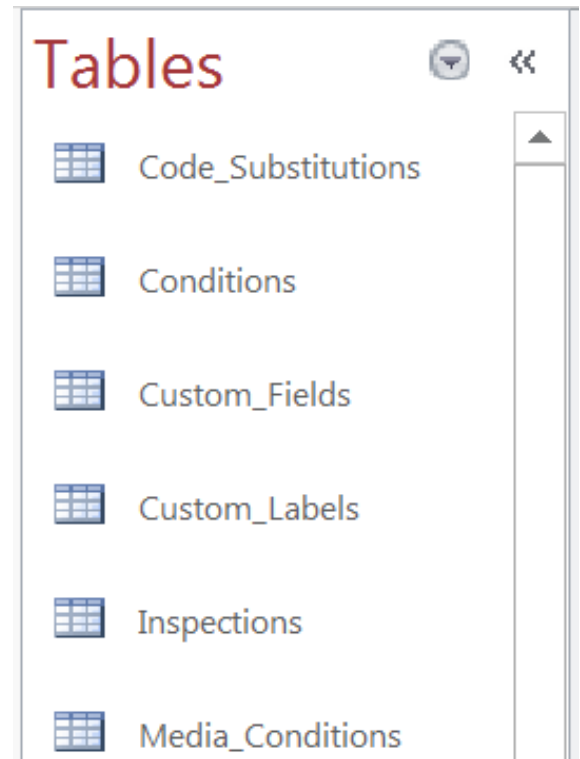
Third Database (LC)

- Coding System: PACP 6
- Data Structure: PACP 6
- Inspections: 2996
- Conditions: 28405
- Main Problems:
 - Duplications
 - Separate Databases

-  Large Diameter Interceptors 2015.MDB
-  LASA 2008.MDB
-  LASA 2009.MDB
-  LASA 2010.MDB
-  LASA 2011.MDB
-  LASA 2012.MDB
-  LASA 2013.MDB
-  LASA 2014.MDB
-  LASA 2015.MDB
-  Mid Size Interceptors 2015.MDB


Forth Database (TU)


- Coding System: PACP 4.2
- Data Structure: PACP 4.2
- Inspections: 46091
- Conditions: 365659
- Main Problems:
 - Incompatibility







Fifth Database (LA)

- Coding System: PACP 6
- Data Structure: Software Preference
- Inspections: 7587
- Conditions: 99596
- Main Problems:
 - Separate Databases
 - Data Structure




 CCTV_2015PACP.mdb







 CCTV_2016PACP.mdb

Tables		
	AI_T	Table
Date Created: 7/29/2008 3:36:27 PM Date Modified: 4/15/2016 9:50:32 AM		
	AIC_T	Table
Date Created: 7/29/2008 3:36:27 PM Date Modified: 4/15/2016 9:50:32 AM		
	C_T	Table
Date Created: 7/29/2008 3:36:27 PM Date Modified: 8/13/2010 7:53:24 AM		
	DC_T	Table
Date Created: 7/29/2008 3:36:27 PM Date Modified: 7/29/2008 3:36:28 PM		

Sixth Database (BA)

- Coding System: PACP 6
- Data Structure: PACP 6
- Inspections: 40966
- Conditions: 522400
- Main Problems:
 - 22,084 Input Errors / 12,115 Inspections
 - Separate Databases

 StandardPacpExchange.mdb
 StandardPacpExchange2.mdb
 StandardPacpExchange3.mdb

Tables		⌵
	Code_Substitutions	
	Conditions	
	Custom_Fields	
	Custom_Labels	
	Inspections	
	LACP_Conditions	

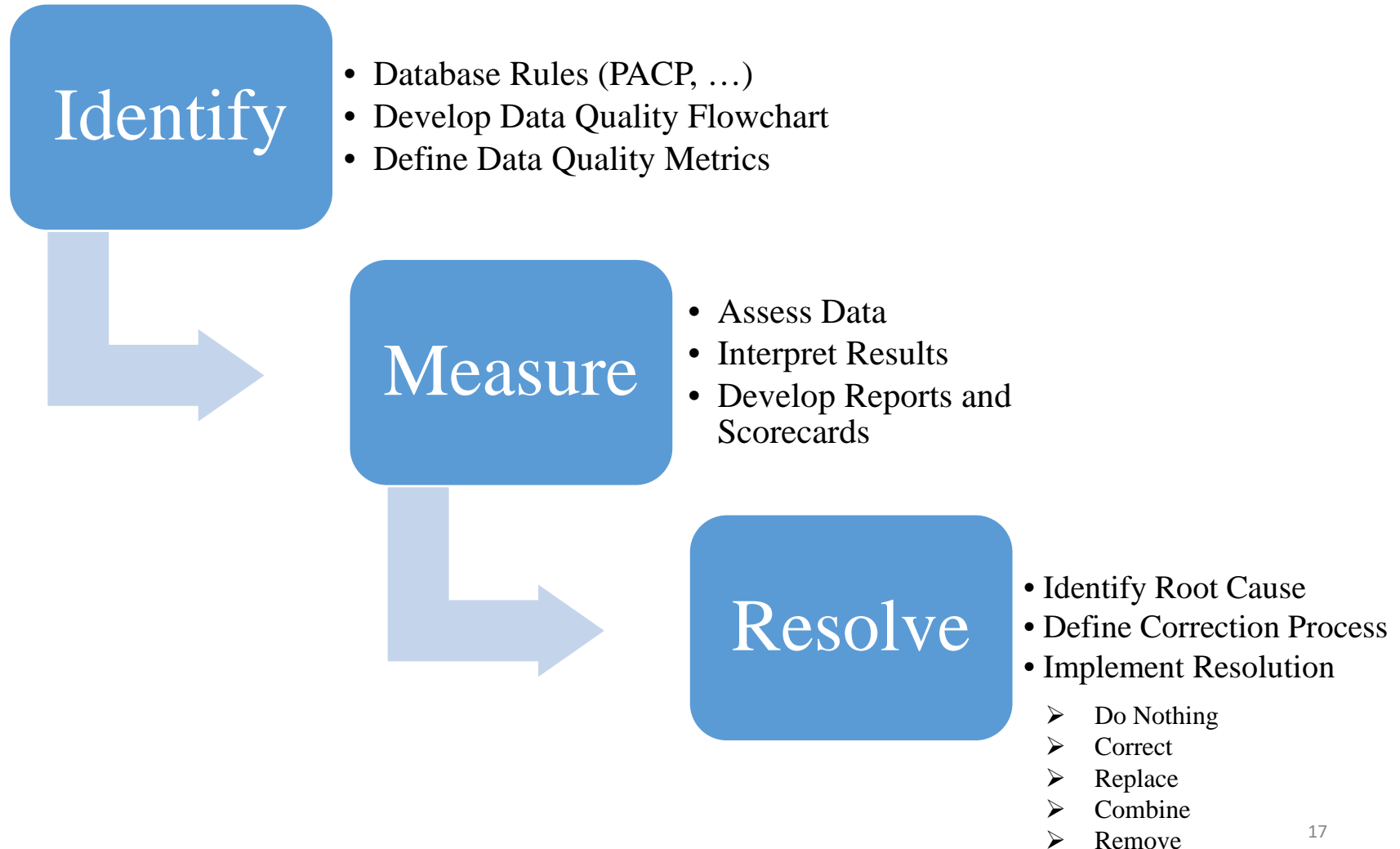
Data Quality Assurance

- The goal of data quality assurance is to reach a high level of accuracy in the PACP inspection data and make it consistent with other datasets.
- This process is a significant step in developing a sewer data inventory by integrating existing datasets.
- High quality data are necessary for decision-support systems, design analysis, and research.
- Technology-only approaches are not sufficient to provide sustained data quality improvements.
- Data quality cannot be improved independently of the source or the context in which these data are used.

Data Quality Assurance

- In order to develop proper QA procedures for PACP datasets, the collected data were reviewed to detect any data quality problems.
- By reviewing the PACP data with the help of NASSCO consultants, the major issues in the database were determined.
 - Pipe grading system
 - Duplicated data

Data Quality Process



Sewer Inspection Data Quality Concerns

- Data developed by different inspectors and not consistent
- Software incompatibility
- Increase use of data as a decision support tool
- Accessibility of data
- Implementation of the PACP standards

Data Quality Metrics

- Metrics should be insensitive to changes in the number of records in the database;
- Metrics should accurately reflect the degree to which the data meets the associated data quality need;
- Metrics should be independent of each other, so that no two metrics are actually measuring the same effect; and
- The number of metrics chosen should be kept to a reasonable number, as too many metrics can often confuse rather than clarify.
- Metrics should address PACP database rules!

Name	Description
Validity	Data element passes all edits for acceptability
Completeness	Data element is required based on the condition of another data element and database rules
Consistency	Data element is free from variation and contradiction based on the condition of another data element
Uniqueness	Data element is unique (duplicate values)
Timeliness	Data element represents the most current information
Accuracy	Data element values are properly assigned

PACP Rules

Code	Value S/M/L	Value 1st	Value 2nd	Value %	Clock At/From	Clock To
CC	NR	NR	NR	NR	R	R
CL	NR	Length (O)	NR	NR	R	NR
CM	NR	NR	NR	NR	R	R
CH2	NR	NR	NR	NR	R	R
CH3	NR	NR	NR	NR	R	R
CH4	NR	NR	NR	NR	R	R
CS	NR	NR	NR	NR	R	R
FC	NR	NR	NR	NR	R	R
FL	NR	Length (O)	NR	NR	R	NR
FM	NR	NR	NR	NR	R	R
FH2	NR	NR	NR	NR	R	R
FH3	NR	NR	NR	NR	R	R
FH4	NR	NR	NR	NR	R	R
FS	NR	NR	NR	NR	R	R
B	NR	O	NR	NR	R	O
BSV	NR	O	NR	NR	R	O
BVV	NR	O	NR	NR	R	O
H	NR	O	NR	NR	R	O
HSV	NR	O	NR	NR	R	O
HVV	NR	O	NR	NR	R	O
D	NR	NR	NR	R	NR	NR
DH	NR	NR	NR	R	NR	NR
DV	NR	NR	NR	R	NR	NR
XP	NR	NR	NR	R (>=40%)	NR	NR

PACP Rules (Example)

B	193
-Should not have a value in Value_Percent	193
BSV	19
-Should not have a value in Value_Percent	19
BVV	53
-Should not have a value in Value_Percent	53
CC	299
-Should not have a value in Value_Percent	299
CH2	7
-Required field Clock_To missing	4
-Should not have a value in Value_Percent	3
CL	474
-Should not have a value in Value_Percent	474
CM	543
-Should not have a value in Value_Percent	543

Duplicates

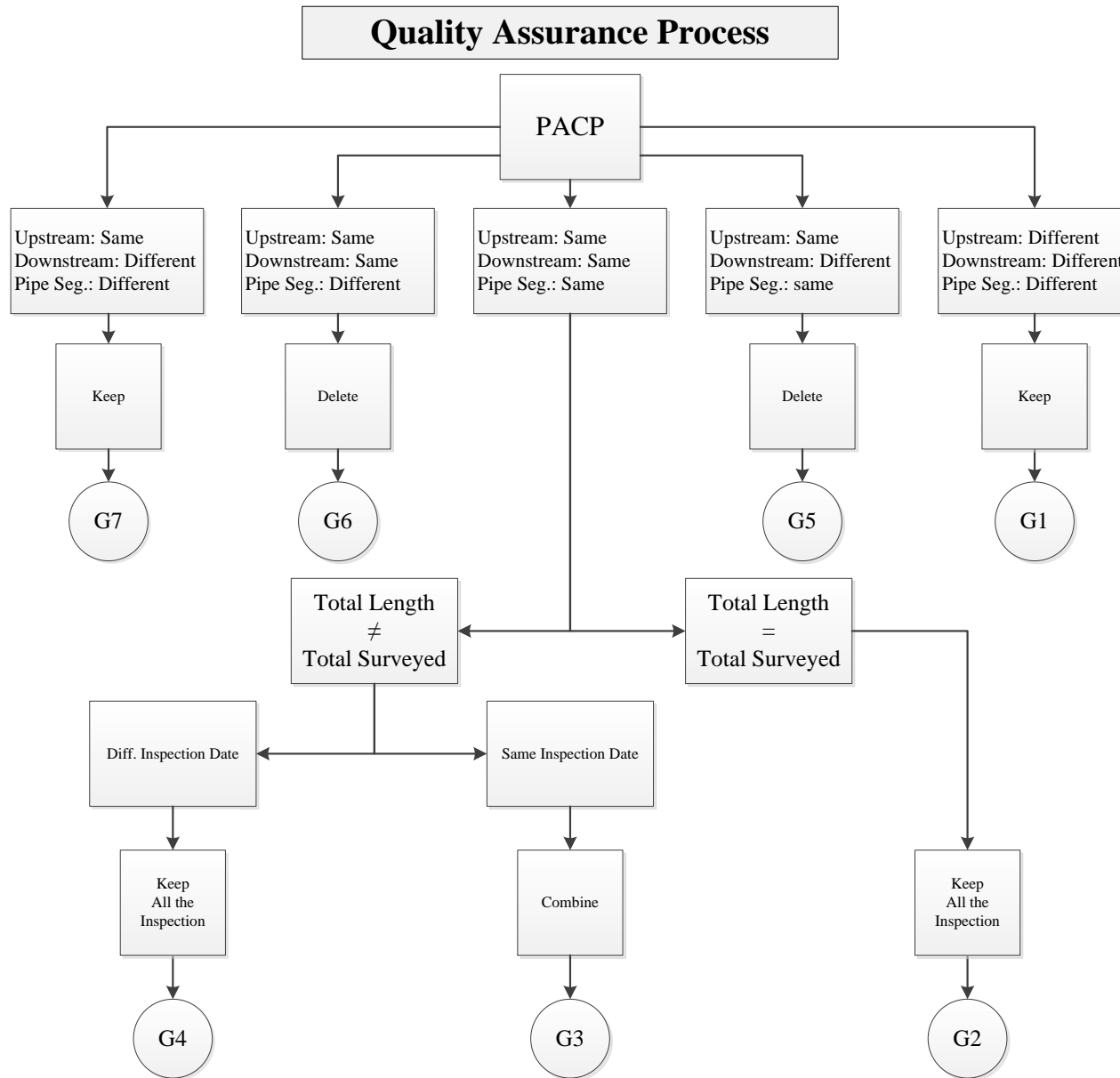
- Common practices to resolve duplicates:
 1. Eliminate duplicate entries (inspection records for pipes with same inspection date (or age) and structural condition rating).
 2. Eliminate inconsistent inspection records (inspection records for pipes with same inspection date (or age) but different condition ratings).

Salman, B. (2010). *Infrastructure management and deterioration risk assessment of wastewater collection systems*

(Doctoral dissertation, University of Cincinnati)

Duplicates

Inspections															
InspectionID	Pipe Segment	Date	Time	Street	USMH	Up_Rim_to_Invert	DSMH	Dn_Rim_to_Invert	Direction	Height	Shape	Material	Total_Length	Length_Surveyed	Location_Code
284	C10 007 Y	20070321	12:34	Lincoln Pkwy	C10 007	10.5	C10 008	0	Downstream	10	Circular	Vitrified Clay Pipe	242	242	Light Hwy
3429	C10 007 X	20120319	12:50	6935 Lincoln Pkwy	C10 007	11.5	C10 008	12	Downstream	10	Circular	Vitrified Clay Pipe	?	86.7	Yard
3431	C10 007 X	20120320	8:38	6935 Lincoln Pkwy	C10 007	11.5	C10 008	12	Upstream	10	Circular	Vitrified Clay Pipe	?	154.5	Yard



Application of Data Quality Assurance for Duplicates

- Second Database (SUD)
- Inspections:212
- Duplicate Inspections 52
- Deleted Inspection:2 (Instead of 52)

QA Groups	Number
G2	3
G3	23 (46/2)
G4	1
Deleted	2

PACP Grading System

- The PACP rating system focuses on the structural and operational condition of sewer pipes.
- Defects are classified into four different families
 - Structural
 - Operational
 - Construction
 - Other
- Defects are graded from 1 to 5 based on the severity of each defect.

PACP Grading System

- The Pipe Ratings Index (PRI) is the average of the grades within a pipe.

$$PRI = \frac{\sum \text{Grades in the Pipe}}{\sum \text{Defects in the Pipes}}$$

- Defects with various criteria
- Defects with grades “zero”



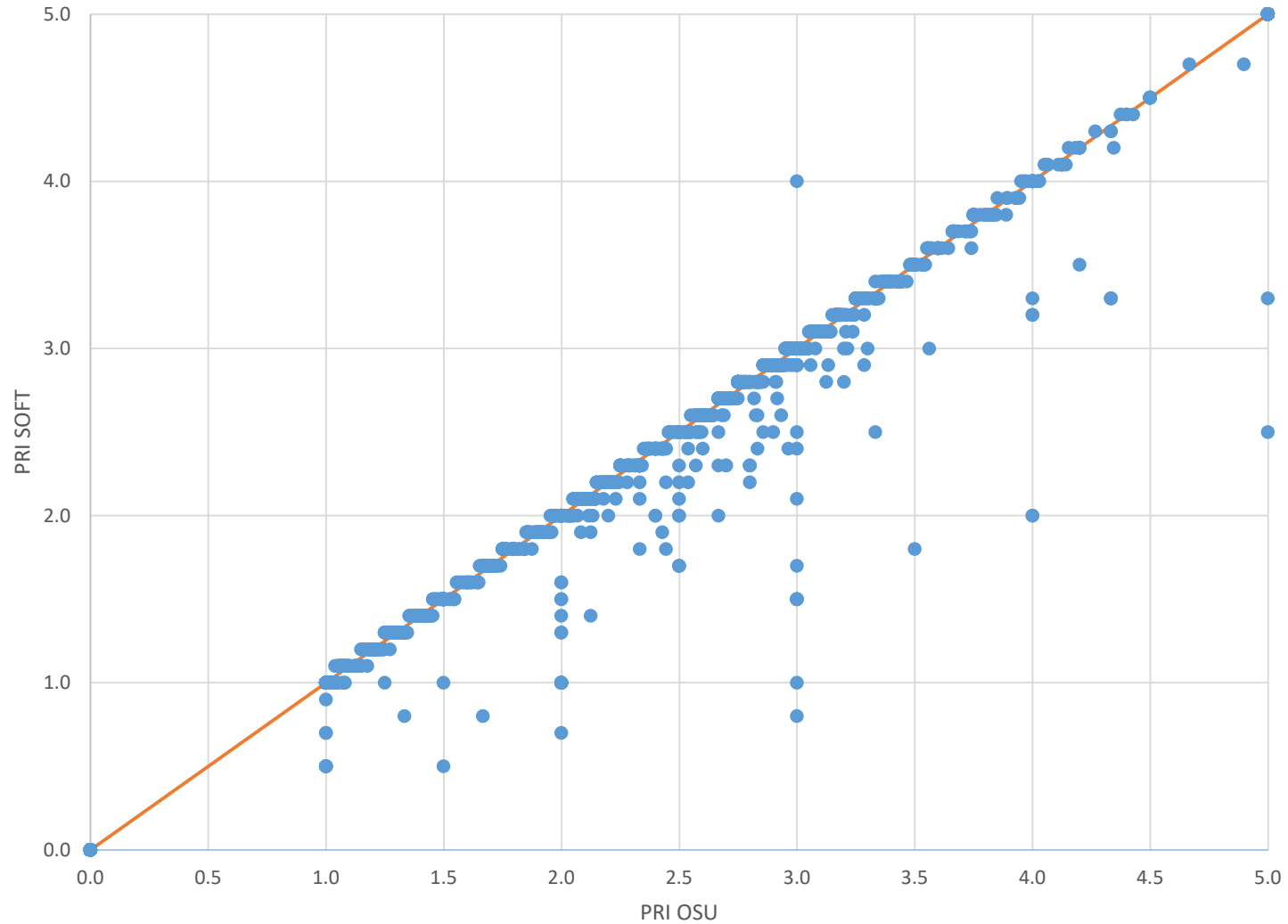
Defects with Grades “Zero”

Inspection 2658 FW

PRI 5 to PRI 2.5

	ConditionID ▾	InspectionID ▾	Distance ▾	Counter ▾	PACP_Code ▾	Continuous ▾	Value_1st_D ▾	Value_2nd_I ▾	Value_Perce ▾	Joint ▾
+	48763	2658	0	0 AMH						<input type="checkbox"/>
+	48764	2658	0	0 MWL					25	<input type="checkbox"/>
+	48765	2658	7	12 DAGS	S01				5	<input type="checkbox"/>
+	48766	2658	7.7	40 DAE					5	<input checked="" type="checkbox"/>
+	48767	2658	14.5	74 TFA			6			<input type="checkbox"/>
+	48768	2658	35.1	157 RPR						<input type="checkbox"/>
+	48769	2658	50.4	252 RPR						<input type="checkbox"/>
+	48770	2658	65.6	532 H						<input type="checkbox"/>
+	48771	2658	70.5	592 DAE					10	<input checked="" type="checkbox"/>
+	48772	2658	81	670 HSV						<input checked="" type="checkbox"/>
+	48773	2658	85.9	796 DAE					15	<input checked="" type="checkbox"/>
+	48774	2658	92.5	834 TFA			6			<input type="checkbox"/>
+	48775	2658	94.6	860 TFA			6			<input type="checkbox"/>
+	48776	2658	100.2	916 DAE					10	<input checked="" type="checkbox"/>
+	48777	2658	122.8	965 MWL					5	<input type="checkbox"/>
+	48778	2658	130.3	1022 DAE					10	<input checked="" type="checkbox"/>
+	48779	2658	172.3	1115 TFA			6			<input type="checkbox"/>
+	48780	2658	174.7	1143 TFA			6			<input type="checkbox"/>
+	48781	2658	175	1190 DSZ					15	<input type="checkbox"/>
+	48782	2658	185	1270 DAE					5	<input checked="" type="checkbox"/>
+	48783	2658	187.3	1296 MWL					40	<input type="checkbox"/>
+	48784	2658	191	1307 DAGS	F01				5	<input type="checkbox"/>
+	48785	2658	212.1	1342 TFA			6			<input type="checkbox"/>
+	48786	2658	216.8	1375 AMH						<input type="checkbox"/>

PRI Comparison



Conclusion

- In order to have an accurate evaluation of the sewer infrastructure condition across the nation, it is required to develop a high quality national sewer inventory.
- Data collection protocols were developed to convince sewer data owners to participate in One-Voice by granting access to their data.
- Moreover, a new data quality assurance process was developed to address the issues within the data and prepare the dataset for integration into the final inventory.
- The PACP grading system, which is widely used to determine pipe conditions in a sewer network, was evaluated in order to avoid inconsistencies in the calculation of ratings.
- To develop a One-Voice prototype database, more sewer data will be collected. After implementation of the new QA process, the new data will be integrated into the prototype database.



THE Event For The Utility Infrastructure Industry

Underground Construction Technology
International Conference & Exhibition

Thank You!

Q & A

