Using AI and Emerging Technologies to Improve Resiliency of Underground Assets

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SAME Fort Worth Post

SPEAKER

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AI/Infrastructure Management
Team Leader

- Water Resources Engineer and Team Leader
- 16 years in Consulting Engineering
- Leads development and implementation of data-driven infrastructure programs
- Leverages data science and machine learning for applications in civil engineering

Agenda

- **HOW CAN AI AND TECHNOLOGY ENHANCE RESILIENCY?**
  - **DATASET DEVELOPMENT**
  - **PREDICTIVE ASSET MANAGEMENT**
  - **QA/QC OF CONDITION EVALUATION**
- **CASE STUDY – SHEPPARD AFB**

AI AND TECHNOLOGY ENHANCE ASSET RESILIENCY

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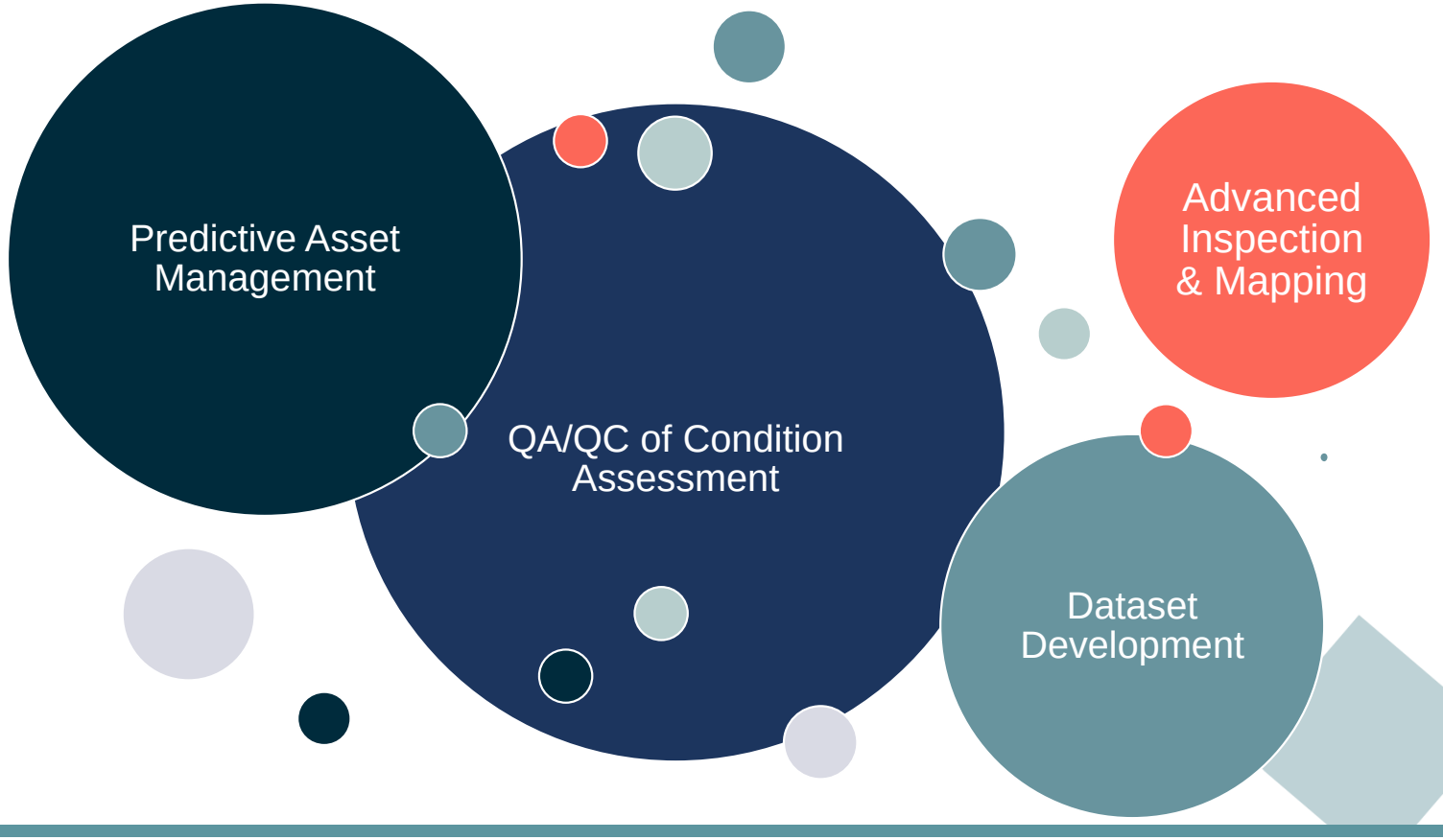

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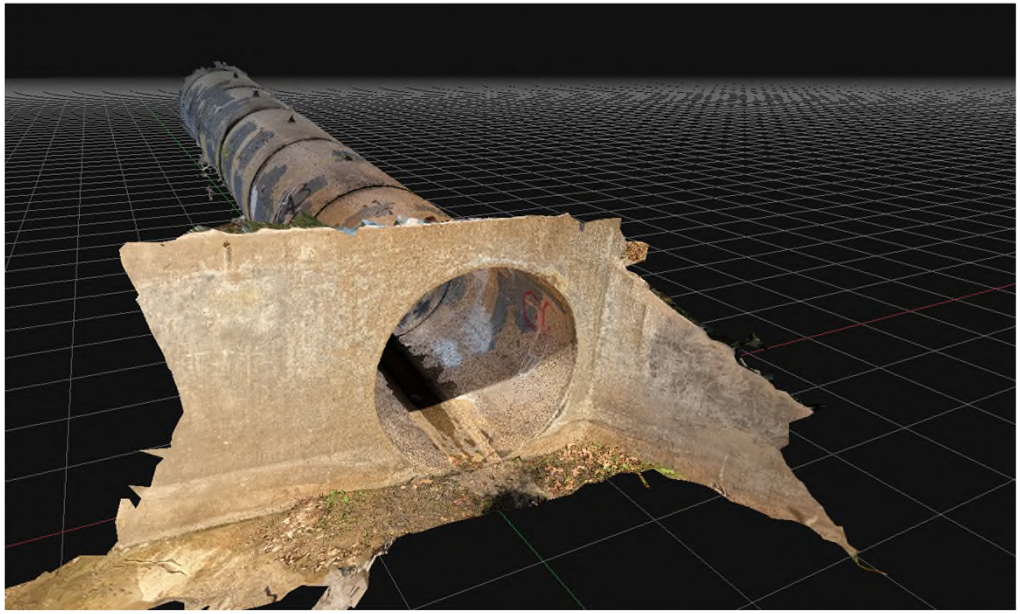
AI AND TECHNOLOGY ENHANCE ASSET RESILIENCY

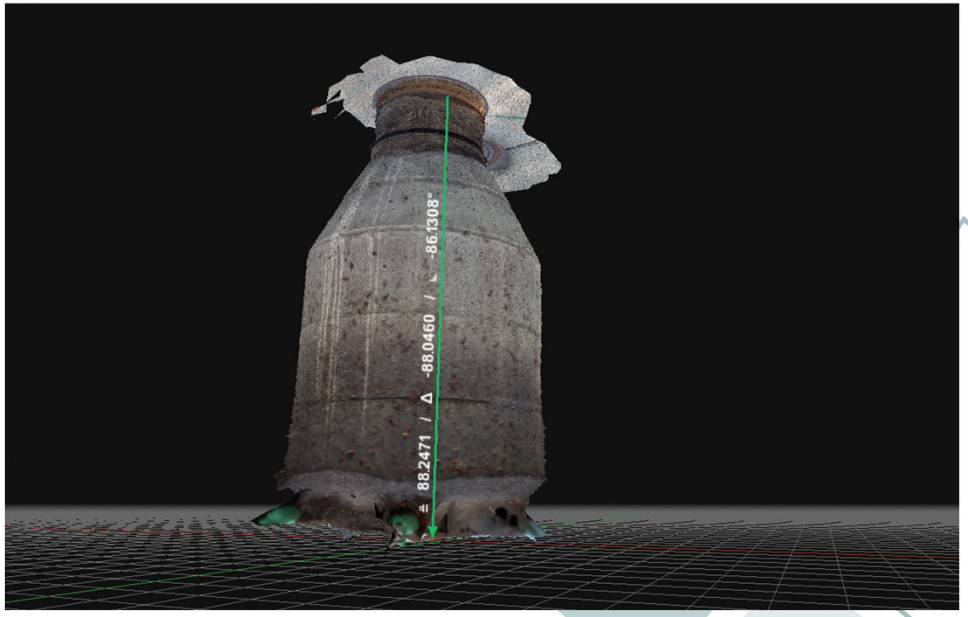
Dataset Development

- **3D digital twins support inventory, condition evaluation, prioritization, & renewal**

Storm Outfall



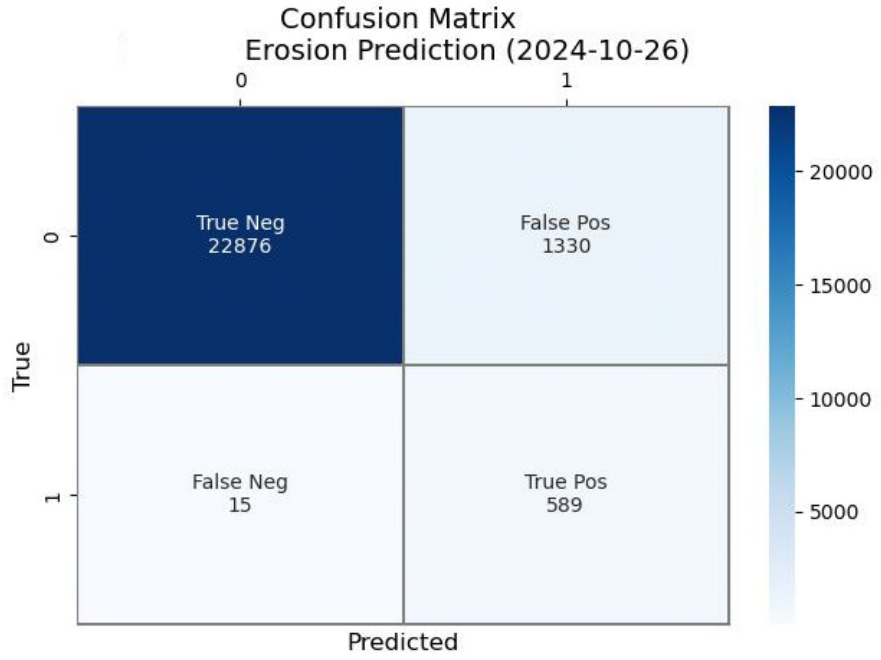
Sanitary Manhole

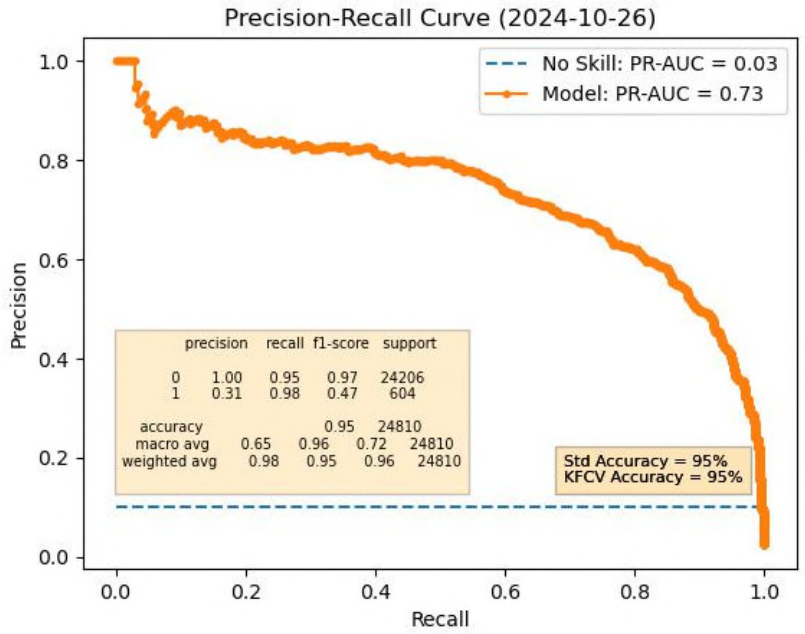


AI AND TECHNOLOGY ENHANCE ASSET RESILIENCY

Predictive Asset Management

- **Machine Learning Metrics**



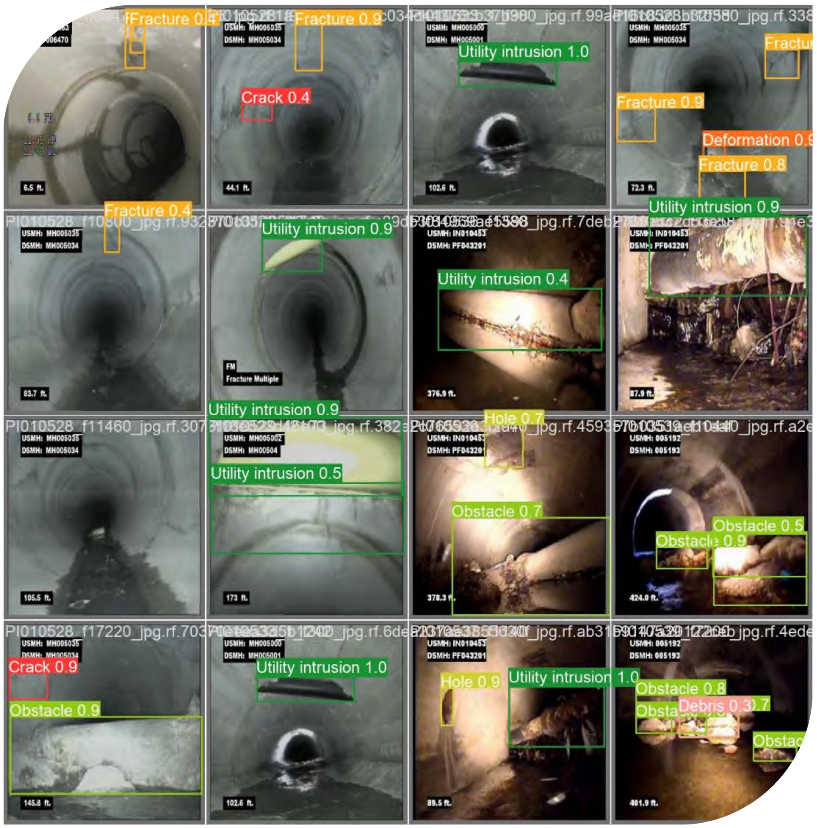


AI AND TECHNOLOGY ENHANCE ASSET RESILIENCY

QA/QC of Condition Assessment

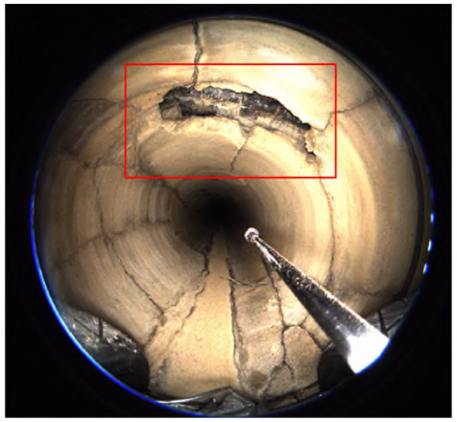
- Pipes
- Access Points

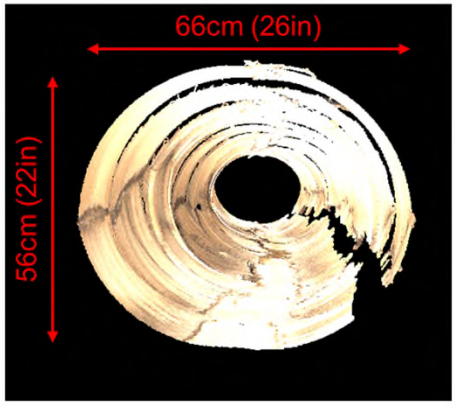
AI Defect QA/QC

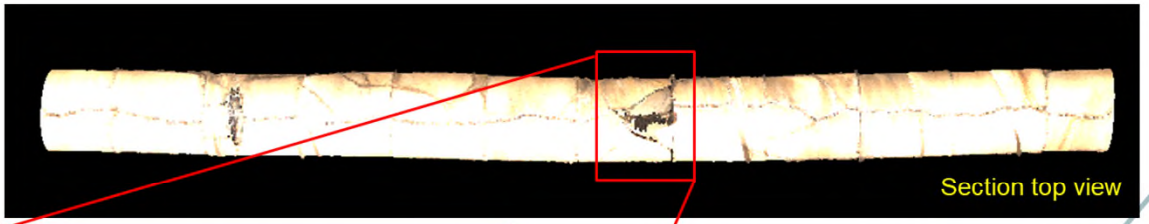


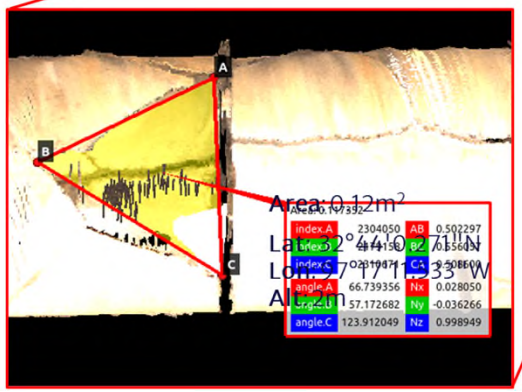
AI AND TECHNOLOGY ENHANCE ASSET RESILIENCY

3D Digital Twins, Scanning, Mapping Horizontal Assets







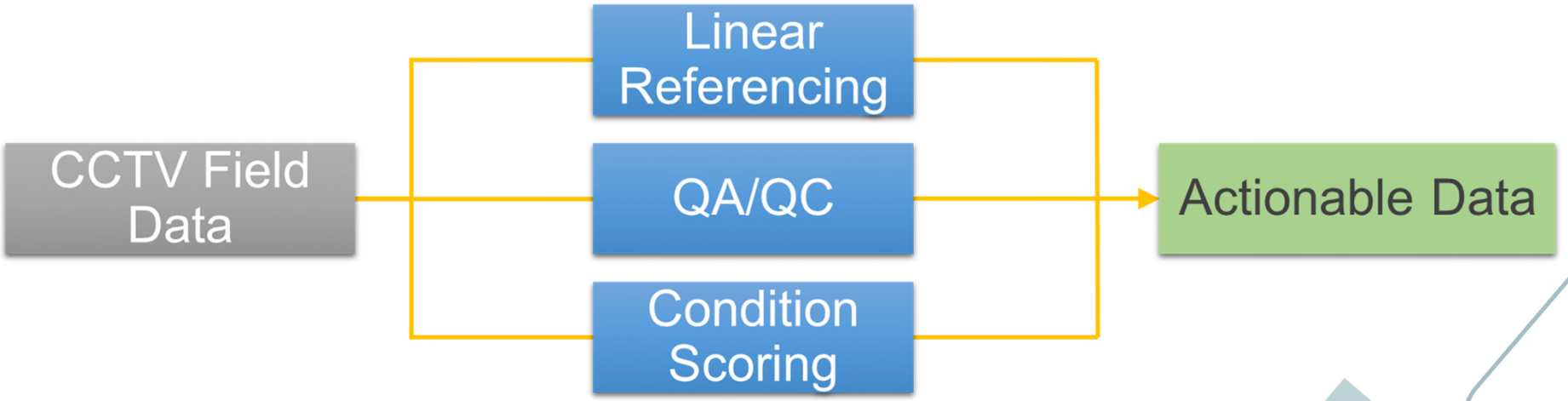


Date: 10/22/2024
Location: Fort Worth, TX
Total Length: 256ft

DATASET DEVELOPMENT

DATASET DEVELOPMENT

Field vs Actionable Data



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DATASET DEVELOPMENT

3D Scanning, Inspection, Scoring, & Topology

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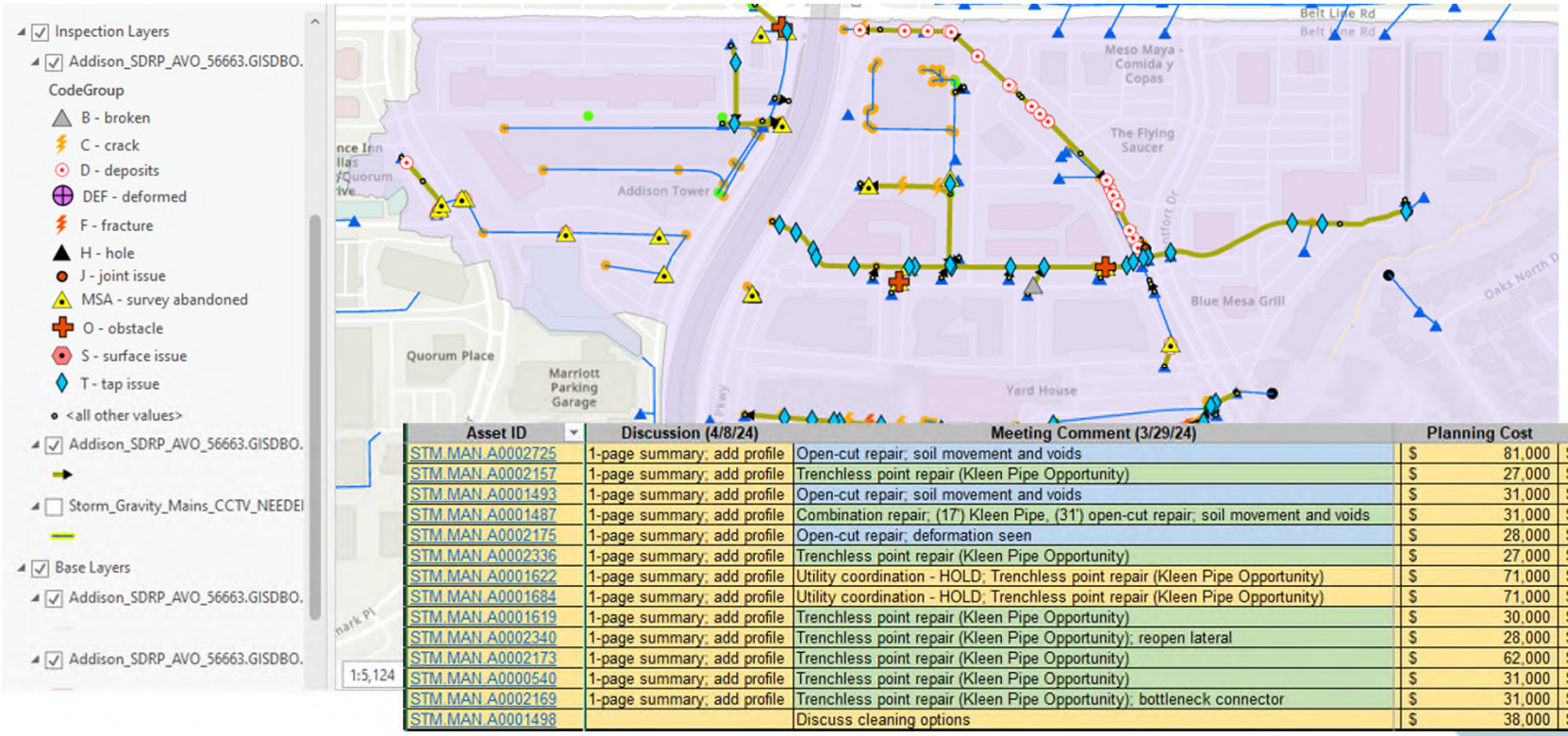
DATASET DEVELOPMENT

GIS, Spreadsheet, Program Documentation



Asset ID	Discussion (4/8/24)	Meeting Comment (3/29/24)	Planning Cost	Revised Cost	High Priority MHs
STM.MAN.A0002725	1-page summary; add profile	Open-cut repair; soil movement and voids	$ 81,000	$ 100,000	1
STM.MAN.A0002157	1-page summary; add profile	Trenchless point repair (Kleen Pipe Opportunity)	$ 27,000	$ 15,000	
STM.MAN.A0001493	1-page summary; add profile	Open-cut repair; soil movement and voids	$ 31,000	$ 31,000	
STM.MAN.A0001487	1-page summary; add profile	Combination repair; (17') Kleen Pipe, (31') open-cut repair; soil movement and voids	$ 31,000	$ 40,000	
STM.MAN.A0002175	1-page summary; add profile	Open-cut repair; deformation seen	$ 28,000	$ 28,000	
STM.MAN.A0002336	1-page summary; add profile	Trenchless point repair (Kleen Pipe Opportunity)	$ 27,000	$ 15,000	
STM.MAN.A0001622	1-page summary; add profile	Utility coordination - HOLD; Trenchless point repair (Kleen Pipe Opportunity)	$ 71,000	$ 15,000	
STM.MAN.A0001684	1-page summary; add profile	Utility coordination - HOLD; Trenchless point repair (Kleen Pipe Opportunity)	$ 71,000	$ 15,000	
STM.MAN.A0001619	1-page summary; add profile	Trenchless point repair (Kleen Pipe Opportunity)	$ 30,000	$ 25,000	
STM.MAN.A0002340	1-page summary; add profile	Trenchless point repair (Kleen Pipe Opportunity); reopen lateral	$ 28,000	$ 18,000	
STM.MAN.A0002173	1-page summary; add profile	Trenchless point repair (Kleen Pipe Opportunity)	$ 62,000	$ 15,000	1
STM.MAN.A0000540	1-page summary; add profile	Trenchless point repair (Kleen Pipe Opportunity)	$ 31,000	$ 15,000	
STM.MAN.A0002169	1-page summary; add profile	Trenchless point repair (Kleen Pipe Opportunity); bottleneck connector	$ 31,000	$ 15,000	
STM.MAN.A0001498		Discuss cleaning options	$ 38,000	$ -	

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DATASET DEVELOPMENT

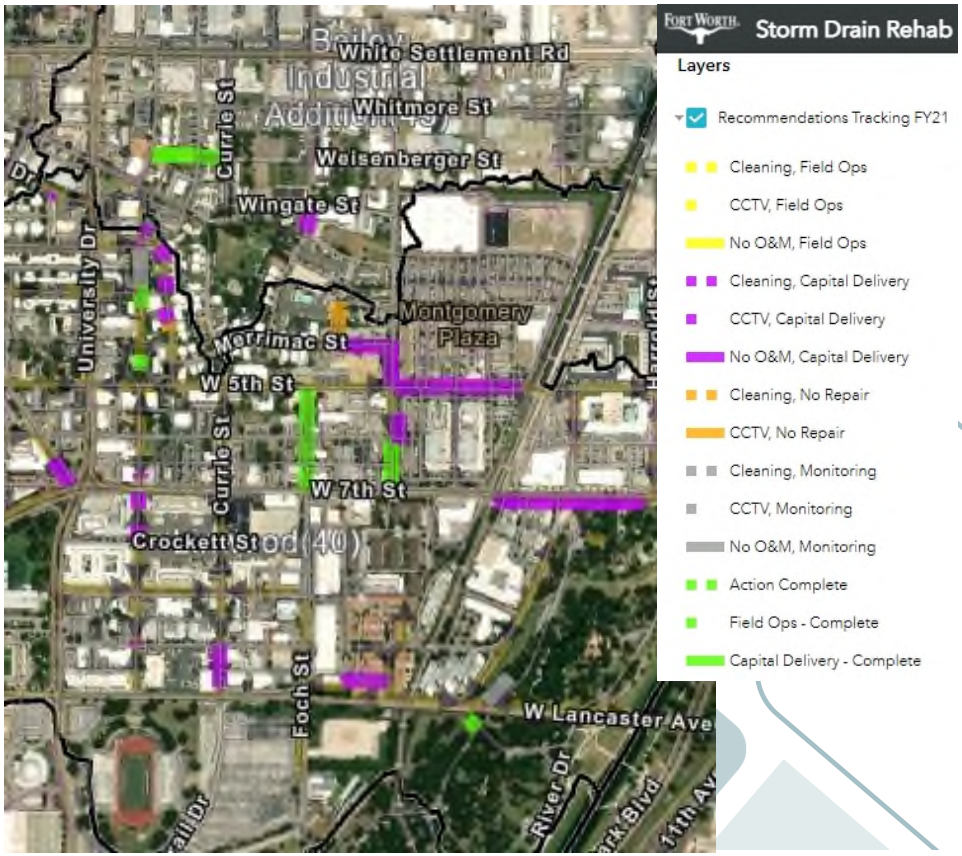
Recommendations & Evaluation

- Data-driven & standardized in GIS or web platform
- Assets evaluated in detail; key inputs for corrective action, responsible group
- Assign corrective action & responsible group (O&M vs structural; City staff vs CIP)

Data-Driven Recommendations

Order	Rule Name	Description
Immediate	10 Rule(s)	
1	Depth Calc	Depth calc from elevations
2	Repair Type	(Structural) Action type is computed based on inputs from other fields
3	Assigned Group	(Structural) Assigned group is computed based on inputs from Repair Type
4	Time Code	Time code is auto-populated based on Response Time
5	Reassigned Group	Assigned group is re-computed based on inputs from Field Ops or Capital Delivery
6	Size Equiv inch	Size calc from diameter or width, converted to inches
7	Action Type Planned	Sets Action Type Planned to "Action Completed" when criteria met; otherwise editable
8	OM Repair Type	(O&M) Action type is computed based on inputs from other fields
9	OM Assigned Group	(O&M) Assigned group is computed based on inputs from OM Repair Type
10	OM Time Code	(O&M) Time code is auto-populated based on OM Response Time

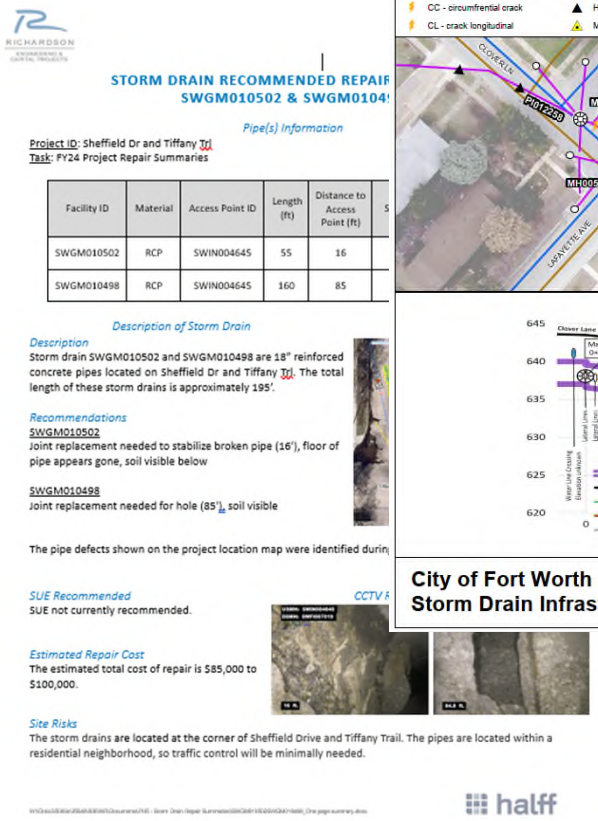
Prioritized Recommendations in GIS



DATASET DEVELOPMENT

Data Handoff

- Site defects, considerations & risks
- Rehabilitation method recommendations
- Plan and profile sheets from CCTV and as-builts



STORM DRAIN RECOMMENDED REPAIR
SWGM010502 & SWGM0104

Pipe(s) Information

Project ID: Sheffield Dr and Tiffany Trl
Task: FY24 Project Repair Summaries

Facility ID	Material	Access Point ID	Length (ft)	Distance to Access Point (ft)
SWGM010502	RCP	SWIN004645	55	16
SWGM010498	RCP	SWIN004645	160	85

Description of Storm Drain

Description
Storm drain SWGM010502 and SWGM010498 are 18" reinforced concrete pipes located on Sheffield Dr and Tiffany Trl. The total length of these storm drains is approximately 195'.

Recommendations
SWGM010502
Joint replacement needed to stabilize broken pipe (16'), floor of pipe appears gone, soil visible below

SWGM010498
Joint replacement needed for hole (85'), soil visible

The pipe defects shown on the project location map were identified durin

SUE Recommended
SUE not currently recommended.

Estimated Repair Cost
The estimated total cost of repair is $85,000 to $100,000.

Site Risks
The storm drains are located at the corner of Sheffield Drive and Tiffany Trail. The pipes are located within a residential neighborhood, so traffic control will be minimally needed.

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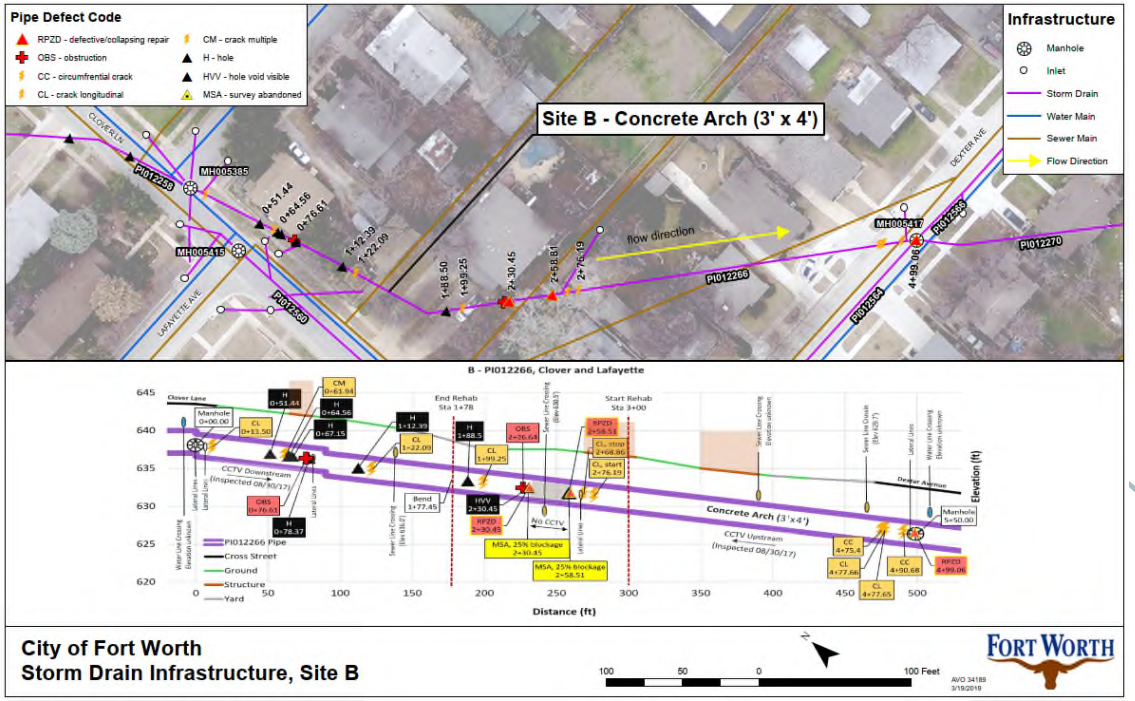
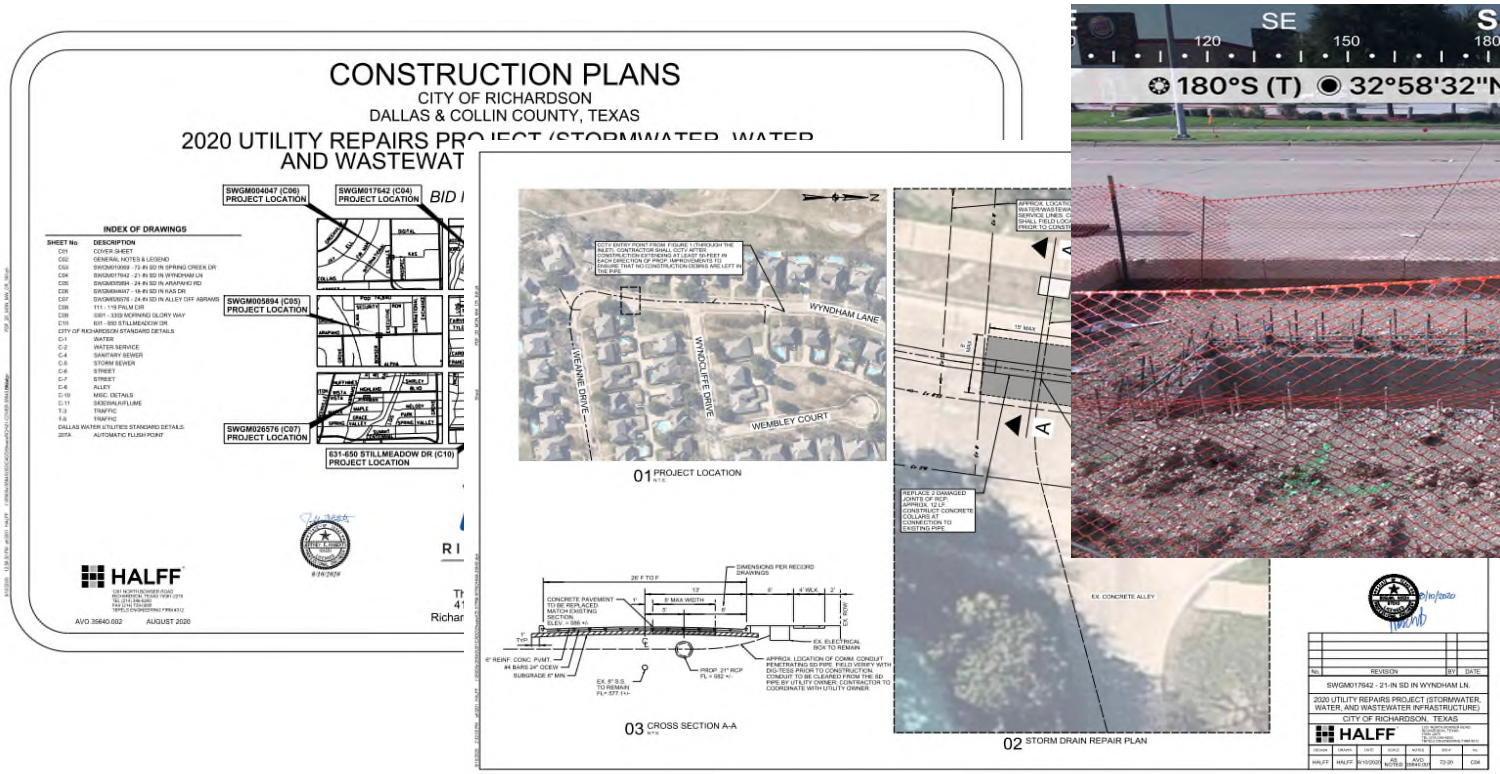


DATASET DEVELOPMENT

Rehabilitation – Open-Cut Design or Trenchless

- Design & bid repairs with collaboration across teams (Water Resources, Public Works, Infrastructure Management, GIS, SUE)



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PREDICTIVE ASSET MANAGEMENT

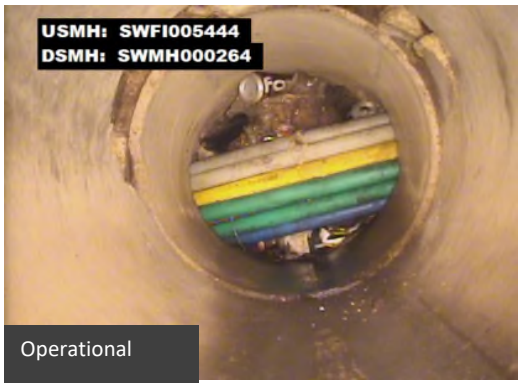
PREDICTIVE ASSET MANAGEMENT

How it Works

- Define Failure - *fail·ure - /ˈfālyər/ - Action or state of not functioning*
- Erosion, structural, operational & conveyance, etc.
- Harness change in assets over time – condition, position, function
- Machine learning model predicts assets and/or locations with high likelihood of failure


Erosion

Structural



Operational

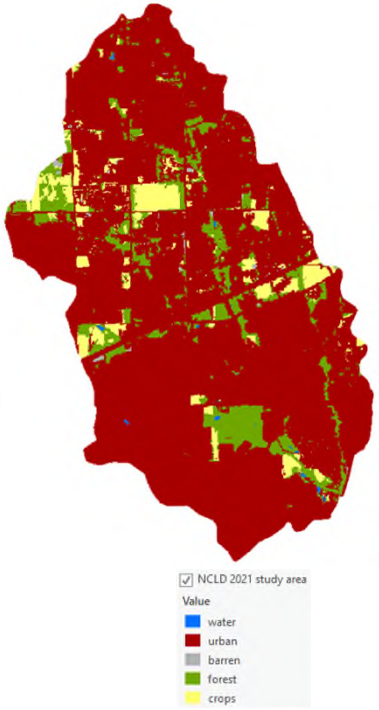
PREDICTIVE ASSET MANAGEMENT

Data Inputs

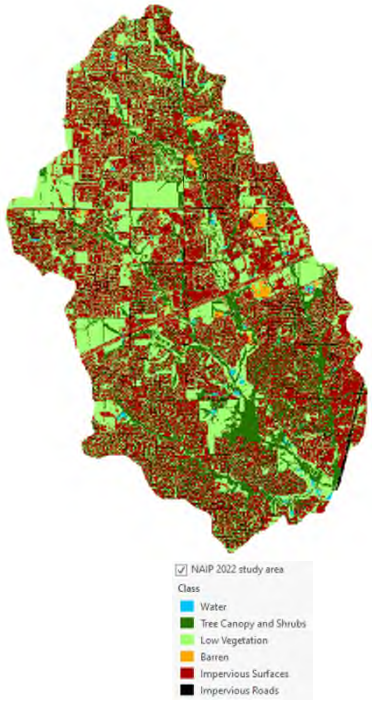
- Spatial datasets - various

Ortho-imagery (NAIP 2022)

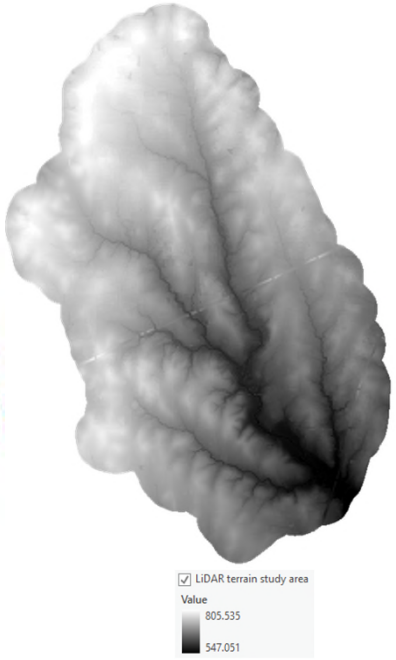
Land Cover (NLCD)



Land Cover (Halff-classified NAIP)



Terrain (LiDAR)

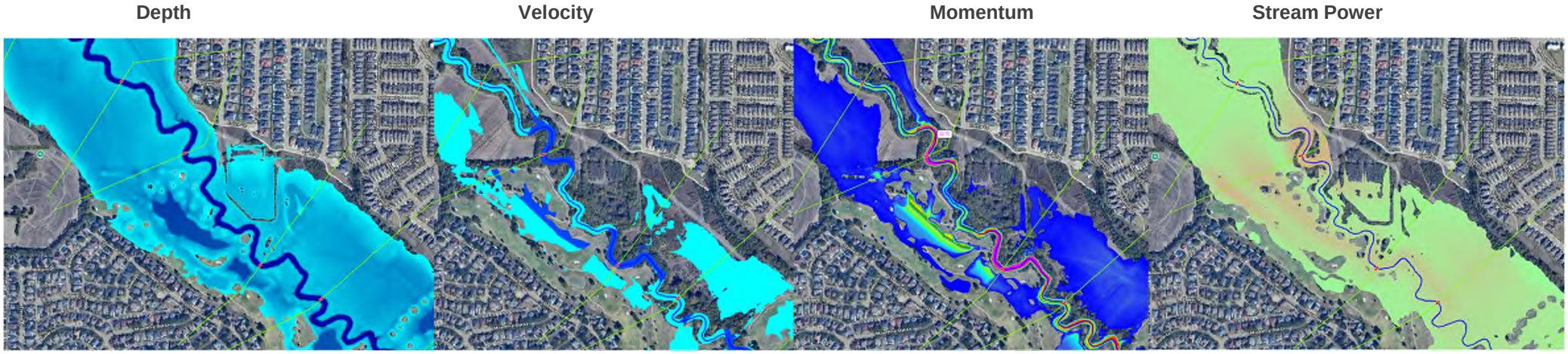


Road Proximity

PREDICTIVE ASSET MANAGEMENT

Data Inputs

- Hydraulic properties
- Existing detailed studies
- Detailed hydraulic models (2D)
- Condition assessment

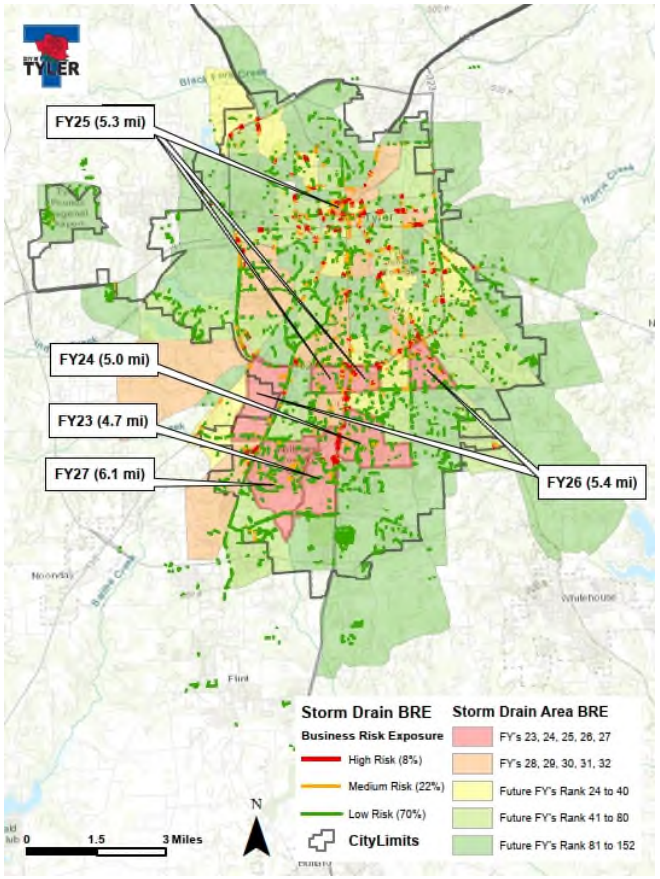


PREDICTIVE ASSET MANAGEMENT

Failure Forecasting

Value Added

- Proactive infrastructure management
- Near-term plan with prioritized action items
- Cost-effective system renewal
- Extends asset life, restores level of service



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PREDICTIVE ASSET MANAGEMENT

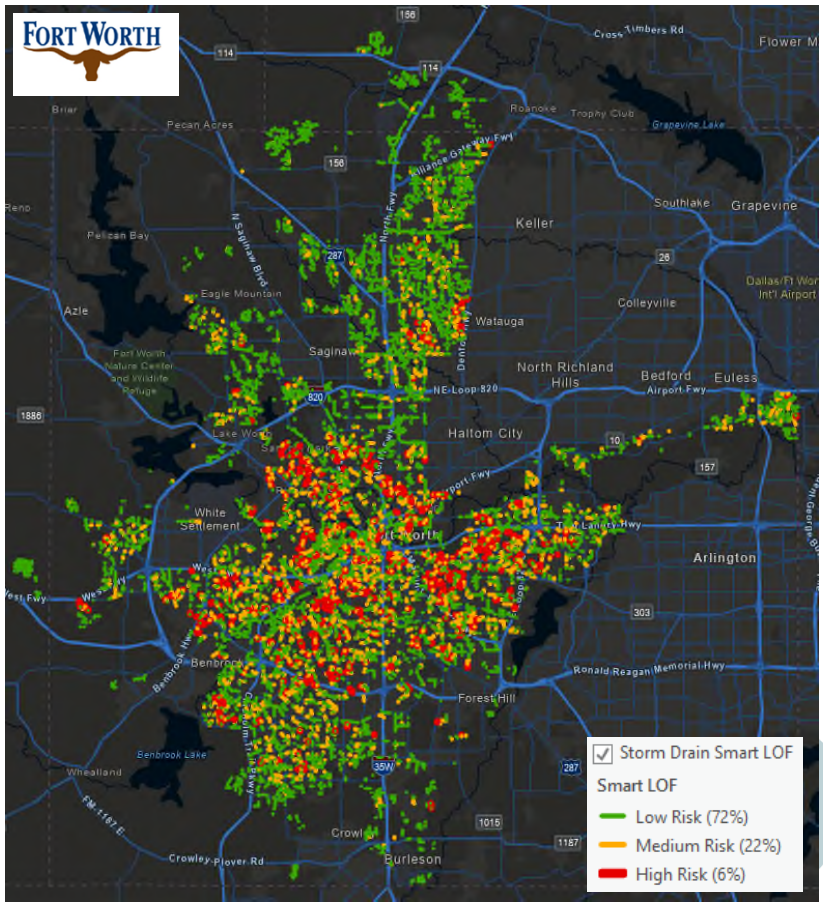
EX: Pipe Failure Forecasting

Advances Traditional Risk Analysis

- Recall (median) = 80% vs 55% with rule-based BRE
- Storm drains in poor condition predicted = 4 of 5
- Future field efforts strategically focused
- Model improves with time

Cross Validation

Recall	CV
85%	1
82%	2
81%	3
81%	4
80%	5
80%	6
79%	7
79%	8
78%	9
76%	10

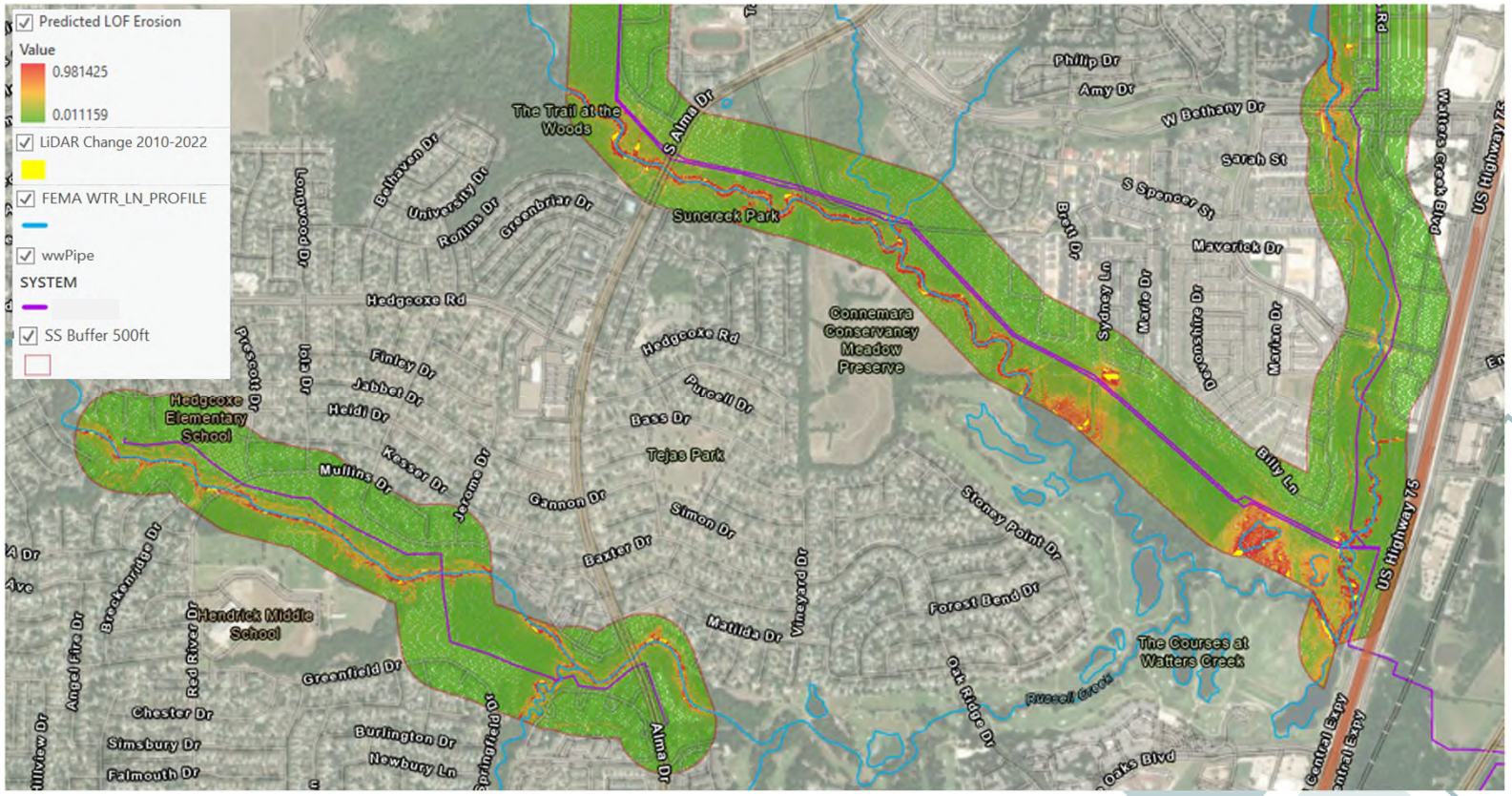


PREDICTIVE ASSET MANAGEMENT

EX: Erosion Forecasting

Advantages

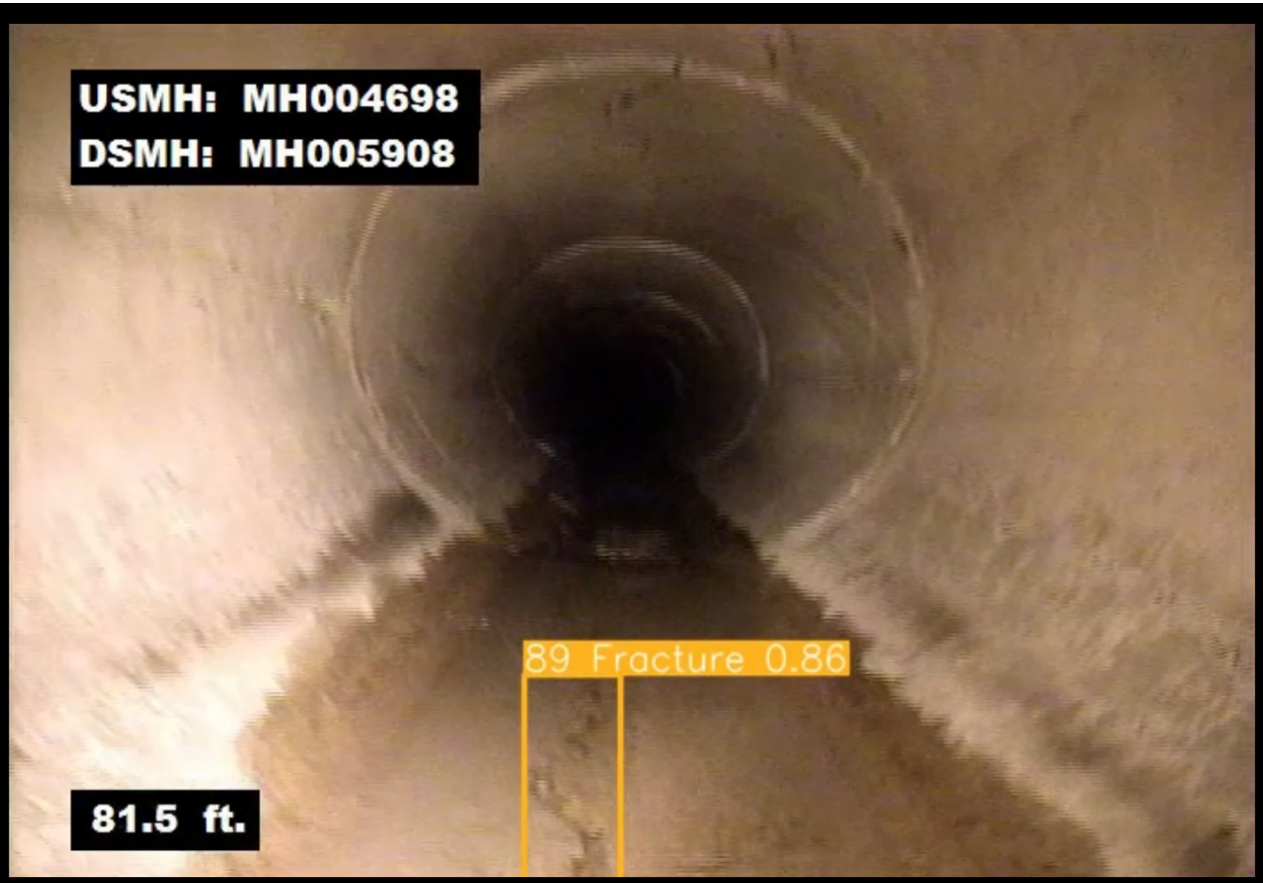
- Predicted Likelihood of Erosion
- Typical model skill ~ 95%



QA/QC OF CONDITION EVALUATION

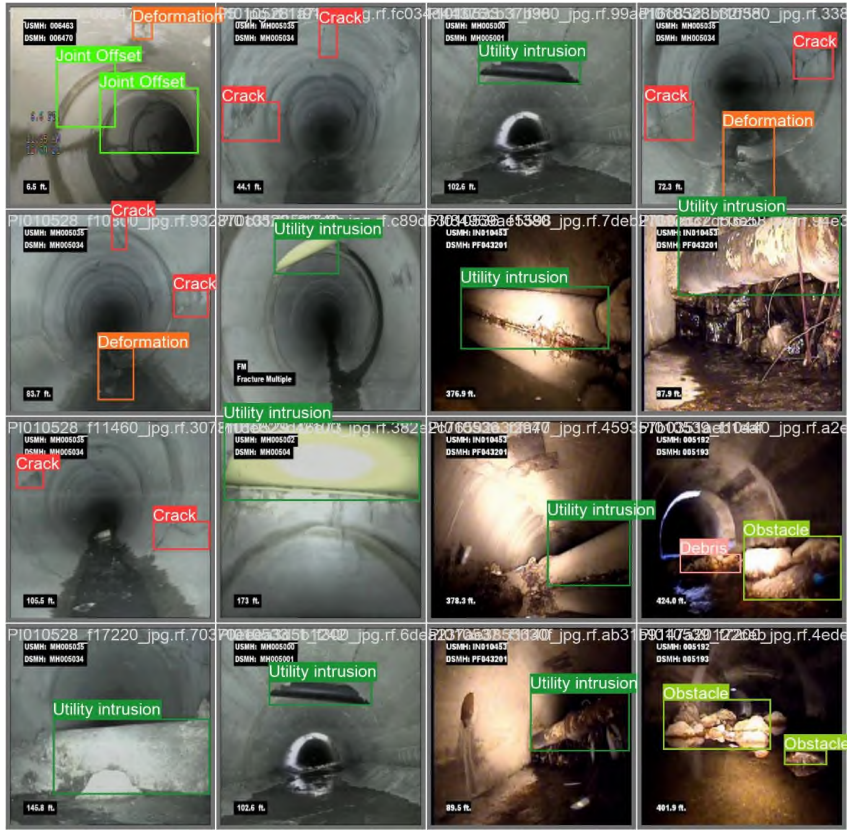
QA/QC OF CONDITION EVALUATION

AI QA/QC Sample



QA/QC OF CONDITION EVALUATION

Labelling/Training

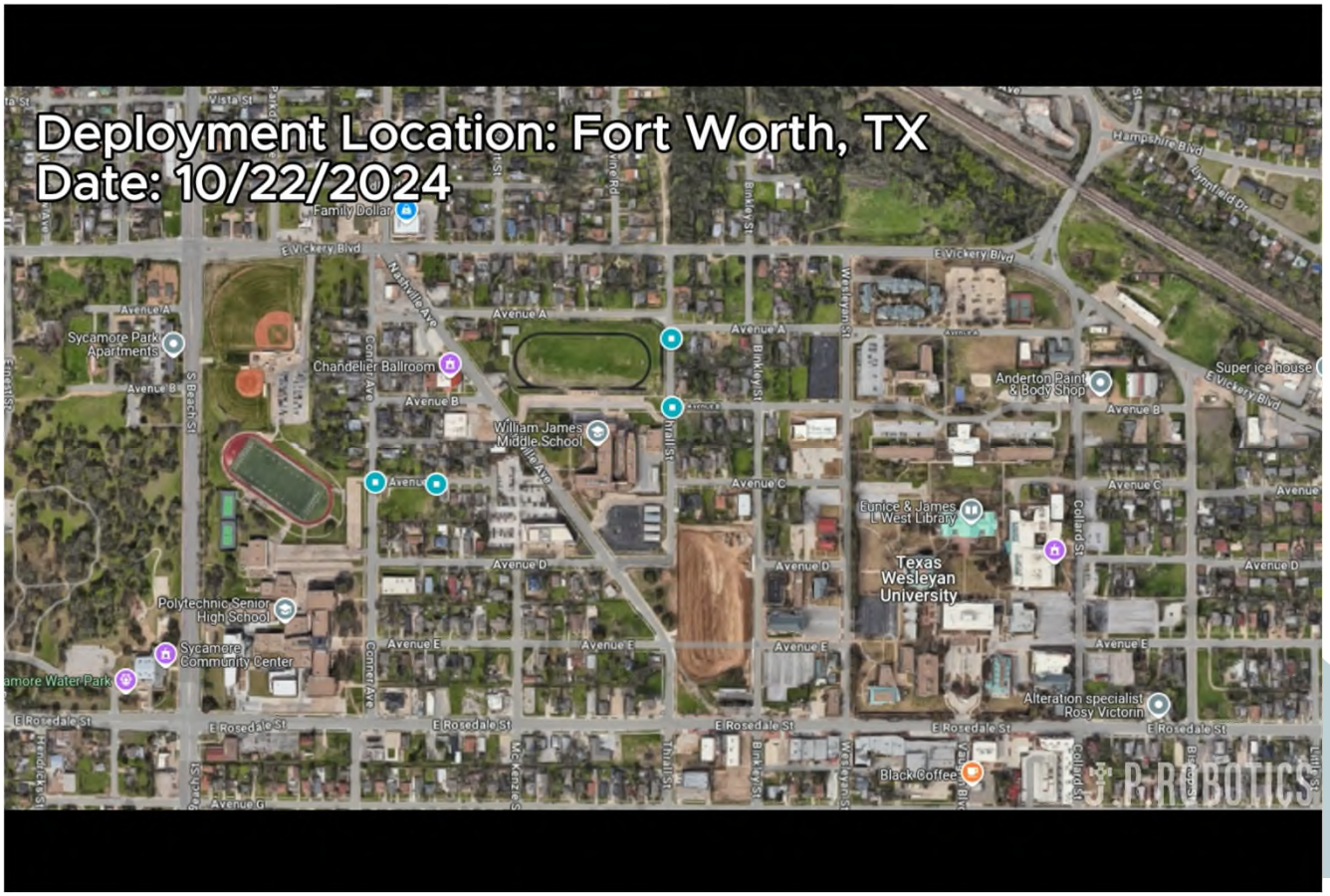


Defect Detection

ADVANCED INSPECTION AND MAPPING

ADVANCED INSPECTION AND MAPPING

Pipe 3D Scanning & Mapping



CASE STUDY - SHEPPARD AFB STORM SYSTEM EVALUATION (2023)

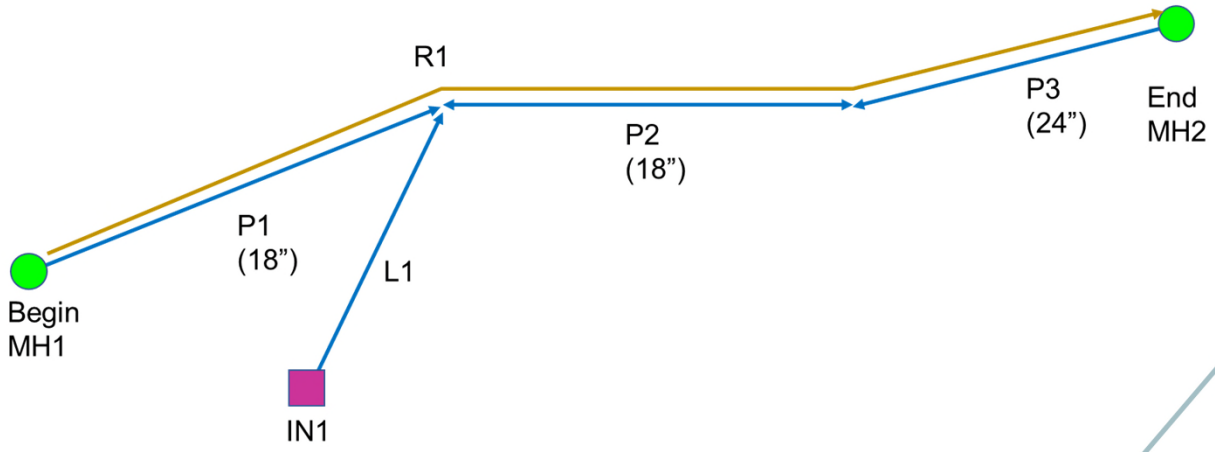
CASE STUDY - SHEPPARD AFB

- **Contracting** - Sheppard Air Force Base contracted SLA-Cyntergy JV and Halff.
- **Goal** - Multi-disciplinary project team leveraged survey, CCTV and manhole inspection, GeoBase integration, and engineering evaluation. Produced high-impact digital asset inventory, evaluation, & drainage modeling in 15-month period of performance.

CASE STUDY - SHEPPARD AFB

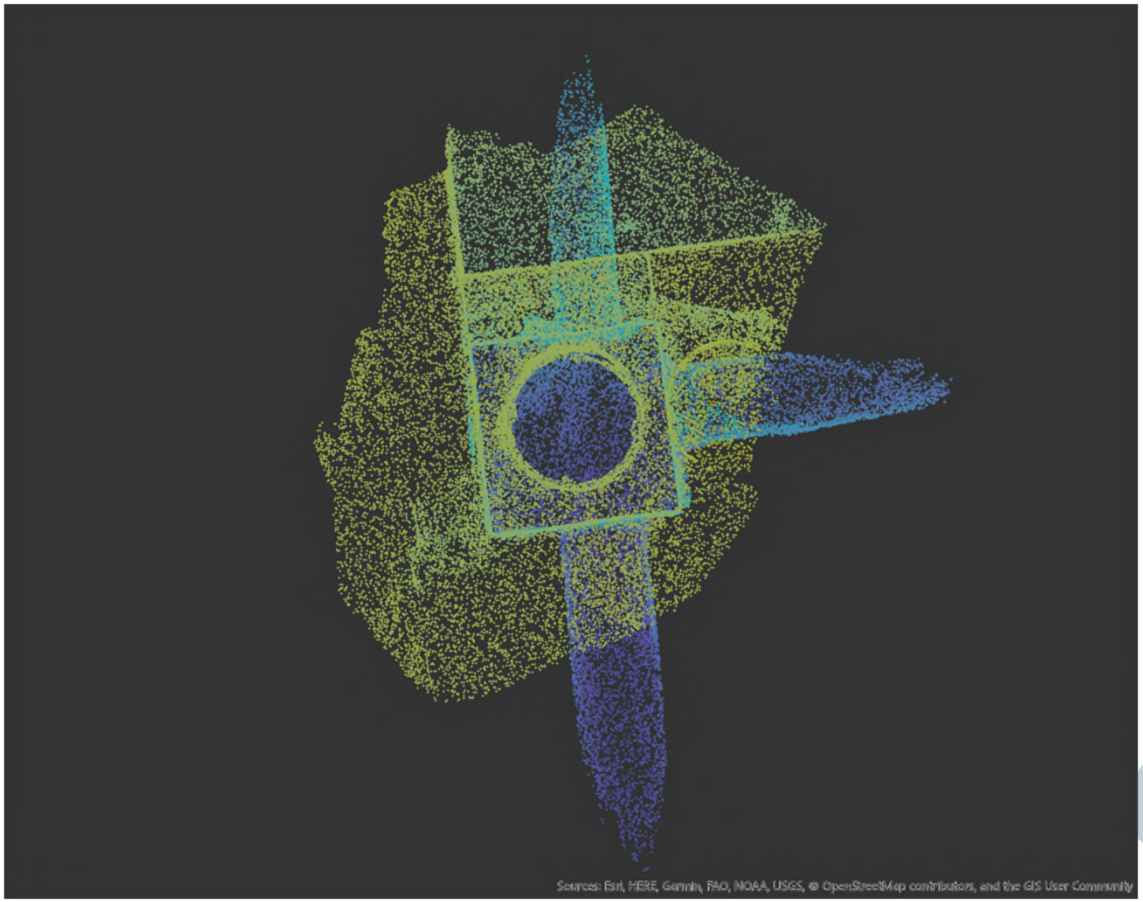
Evaluation Requirements

- Survey = 1,250 point assets (Manholes, inlets, discharge points)
- Condition assessment (CCTV) = 105,000 LF
- Condition assessment (MH Inspection) = 1,150 Manholes



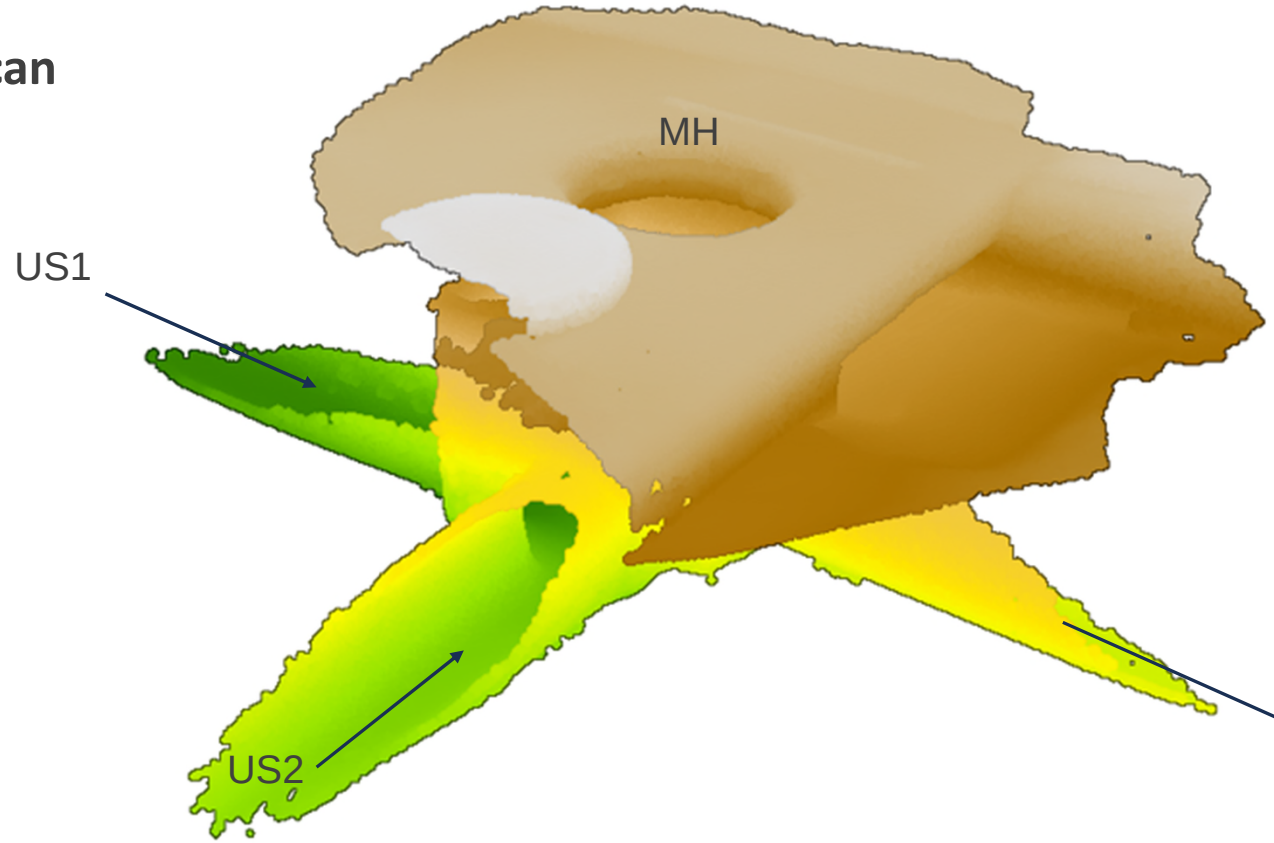
CASE STUDY - SHEPPARD AFB

LiDAR Scan Output



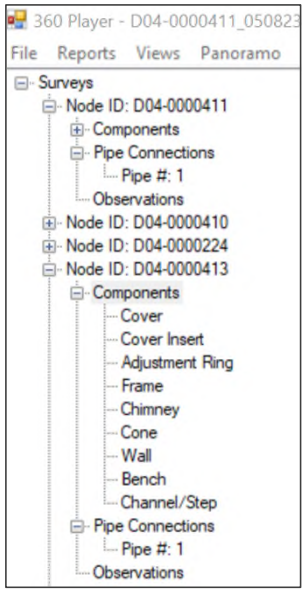
CASE STUDY - SHEPPARD AFB

LiDAR Scan Output



CASE STUDY - SHEPPARD AFB

MH 360 Inspection Output



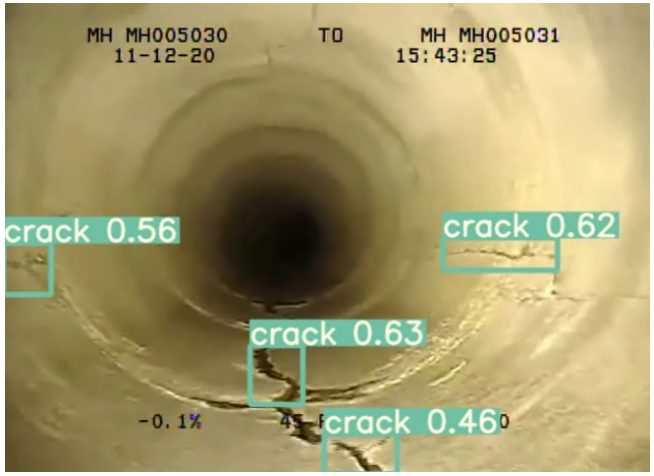
CASE STUDY - SHEPPARD AFB

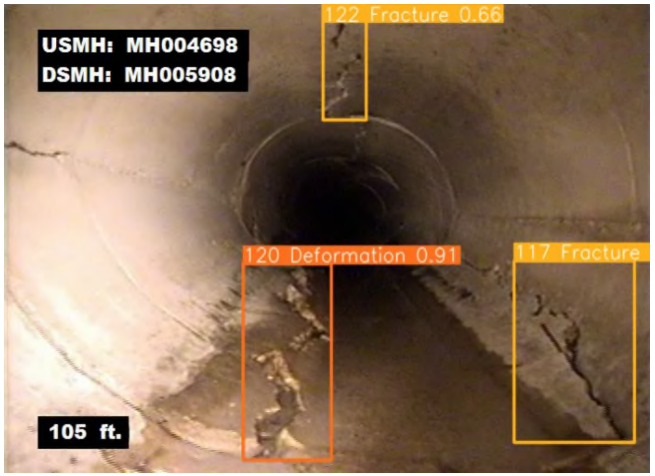
AI QA/QC – Sample #1

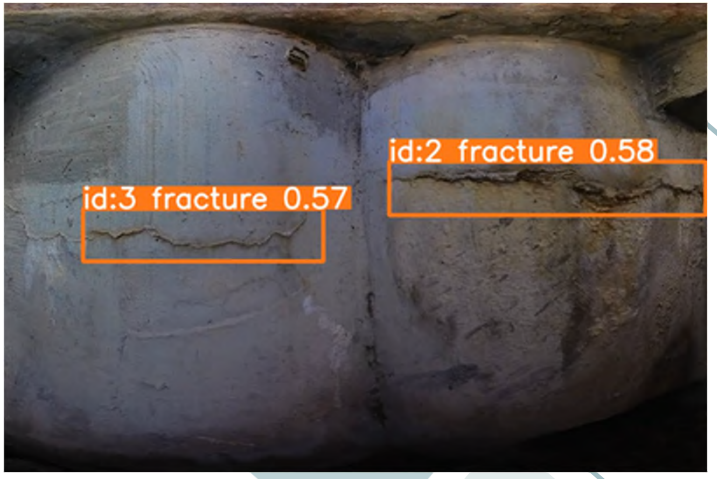
CASE STUDY - SHEPPARD AFB

Quality Assurance and Control

- Data completion and GIS referencing (100%)
- AI “Second opinion” QC (100%) - Pipes & Manholes; Standardized Scoring
- Expert human-in-the-loop review (15-20%)







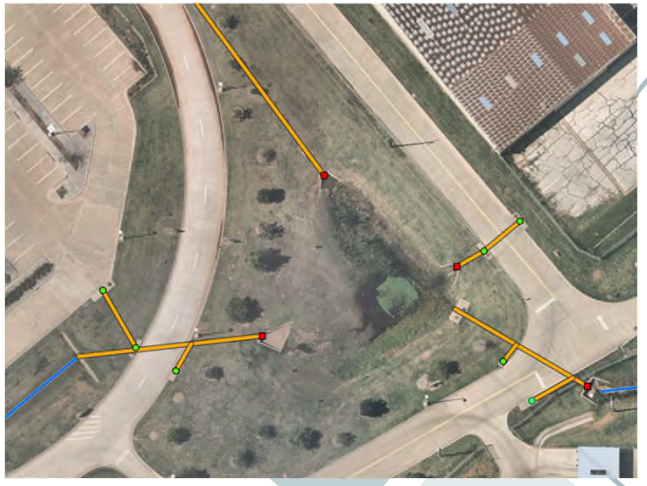
CASE STUDY - SHEPPARD AFB

United States Air Force GeoBase Program

- USAF strategic program
- GIS integration, mission support, and uniformity across installations
- Effective asset tracking & renewal prioritization

U.S. AIR FORCE

Sample corrections



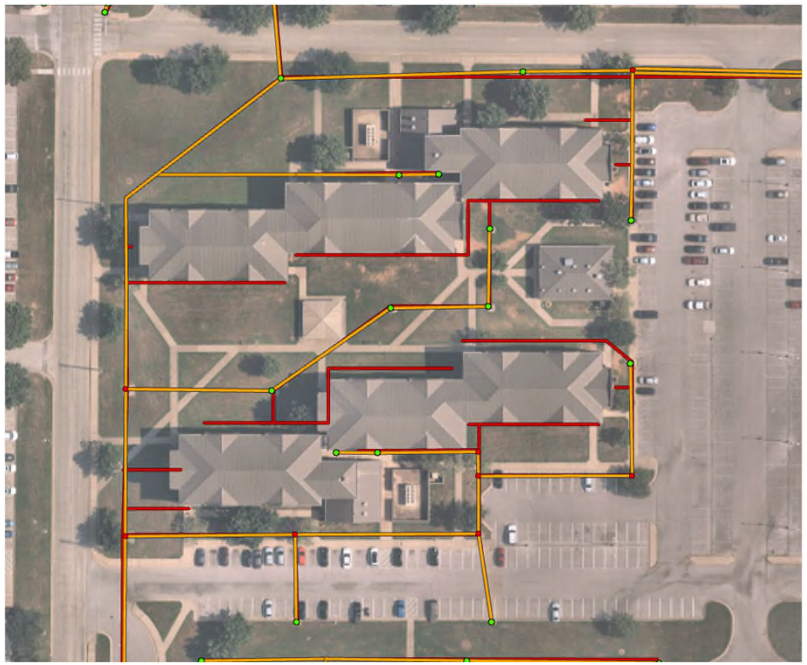
CASE STUDY - SHEPPARD AFB

GeoBase Assets

- Manhole
- Inlet
- Discharge point
- Gravity main
- Open drainage

Data Sources

- Traditional survey
- PACP inspection
- Asset inspections



CASE STUDY - SHEPPARD AFB

Evaluation Process/Considerations

- PACP grades 3 to 5 evaluated
- Storm drains and Manholes independently evaluated for corrective action
- Standardized scoring applied
- Rehab methods matrix – trenchless vs open-cut; O&M vs Structural
- Responsible group, response time (relative), score, rank

Corrosion

Joint Offset

Wall Collapse

Broken Pipe

CASE STUDY - SHEPPARD AFB

Recommendations in GIS Web Platform via Secure Portal

Observation Points | Routes | Halff Survey Locations | SwInlet | SwManhole | SwDischargePoint | SwCulverts | SwGravityLine | SwOpenDrainage | RecommendationsTBL | MH_ConnectionsTBL | MH_InspectionsTBL

Options | Filter by map extent | Zoom to | Clear selection | Refresh

Segment ID	Diameter	Size Equivalent (in)	Code	Description	Grade	Count	Year Inspected	Recommendation	SDCD	Access Point ID	Distance to Access	Grou
D05-0000129		9,999	JOL	Joint Offset Large	4	1	2,023	Joint repair needed to stabilize joint offset (53')	6.83	D04-0000042	7	

711 records 1 selected

CASE STUDY - SHEPPARD AFB

Hydrology and Hydraulics Modeling

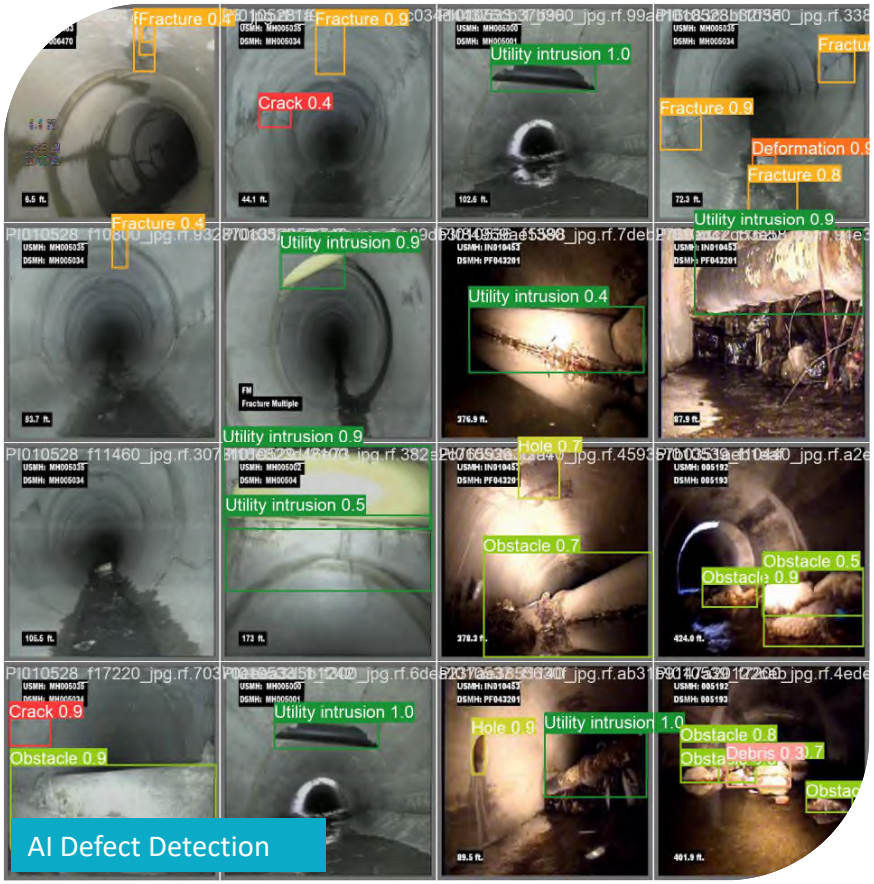
- Autodesk Storm & Sanitary Analysis (SSA)
- HEC-RAS

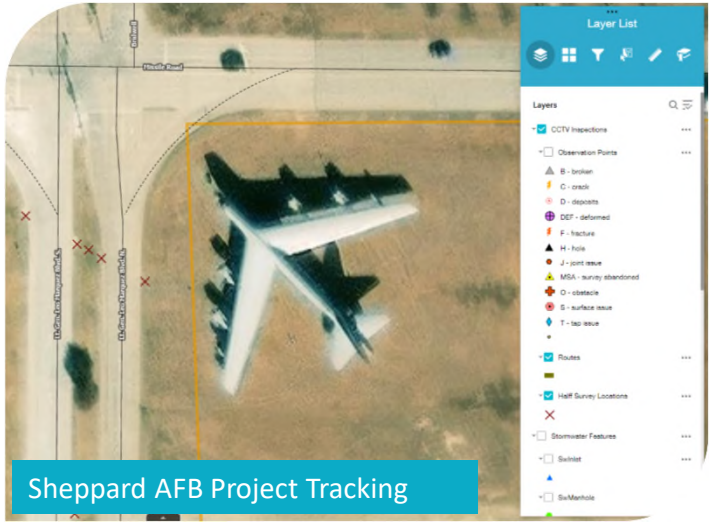
Detailed watershed mapping 1

GeoBase updates and site visits informed drainage network 2

Master plan with future pipe sizes 3

CASE STUDY - SHEPPARD AFB





Lessons Learned

- Communication - multiple disciplines
- Base access, procedures, and training
- Survey then condition assessment
- High-impact deliverables – engage today's technology
- AI application = enhanced efficiency + accuracy
- Resiliency mindset to reduce risk + add value

Q & A

Matt Stahl, PE, CFM, AWAM
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