

3D Design Models to Construction (Data Centric Approach)

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Why e-Construction?

- **INDOT's main initiative was to implement and leverage 3D intelligent Computer Aided Design (CAD) models for AMG, e-Construction and Asset Management**
- **Focus was on the transition from 2D to 3D for their Construction project delivery process aligned with the Federal Highway Administration (FHWA) Every Day Counts program**
- **The main effort has been an emphasis on e-Construction that leverages 3D models in construction and provides as-built asset information to Maintenance Operations**
- **Identify many benefits to INDOT, including cost savings, and improved safety and quality**



Why e-Construction?

- One aspect of e-Construction is to create a document centric approach focused on reducing paper
- INDOT wanted to take this further by adding a data centric approach
 - focuses on the transfer of data from 3D design models to construction
 - and then to asset management



Mission Statement

- The use of intelligent 3D CAD models to support the lifecycle of transportation assets (roads and bridges) that provides predictive analysis and reporting capabilities that is data driven and allows the agency to make better operational and strategic management decisions.



e-Construction

■ FHWA

- Every Day Counts (EDC) Initiative
- Paperless Construction

■ INDOT

- Data Centric Approach
- Leverage findings from study by Purdue University, SPR-3707



The Business Opportunity

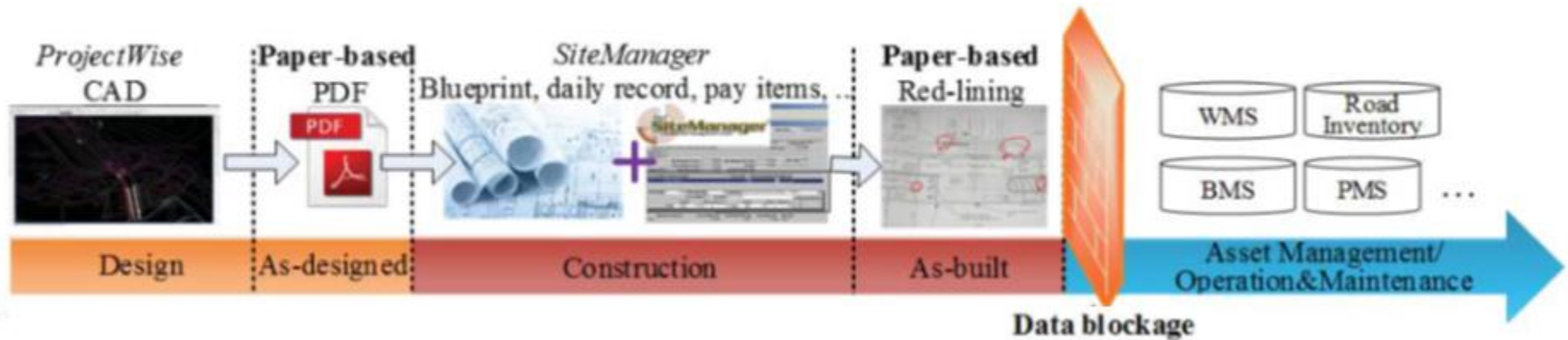


Figure 5.2 Asset data flow in the current practice at INDOT.

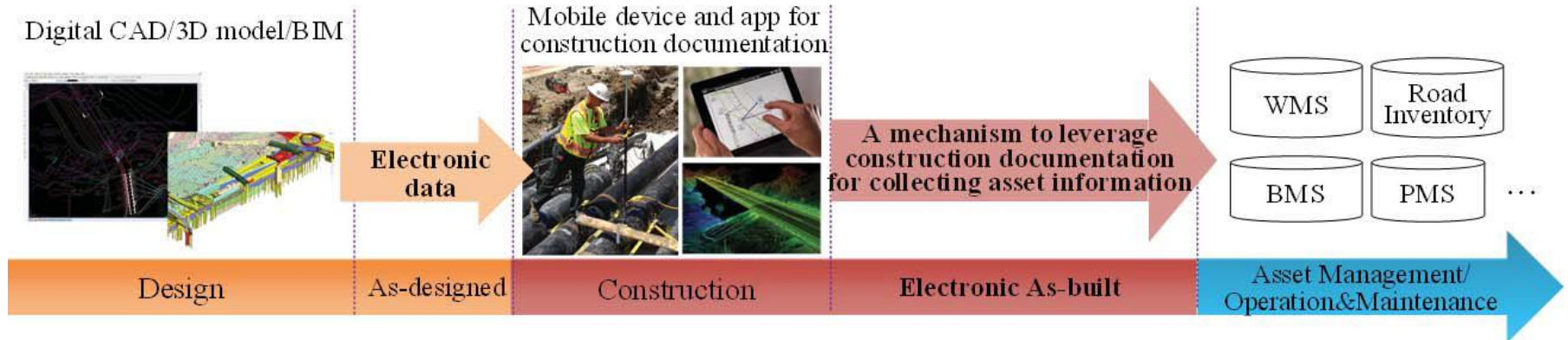
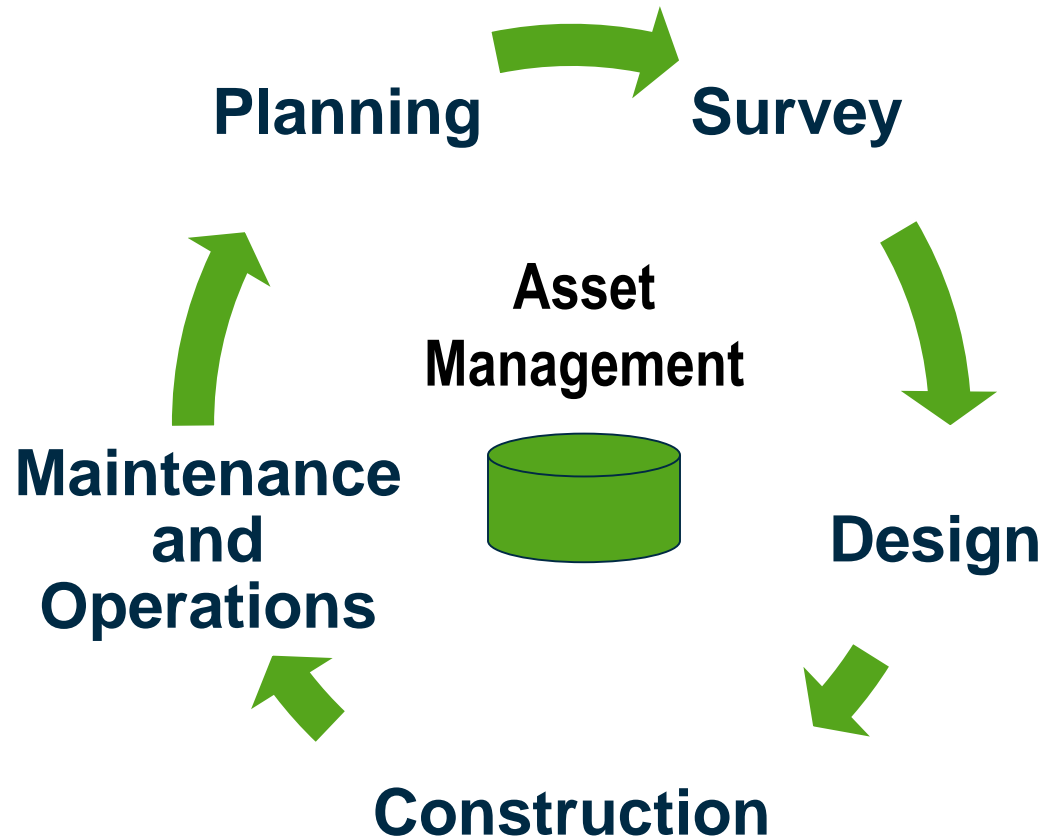


Figure 5.3 The suggested data flow.

3D Model Data Lifecycle



e-Construction Current Efforts

- **CAD Software Platform Upgrade**
- **Gap Analysis Study**
- **HP Tablets Supplied to INDOT Construction Inspectors**
- **Construction Inspection Application**



CAD Software Platform Upgrade

- **Completed by Bentley Systems, Inc.**
 - CAD Workspace and Design Software upgraded from SS2 InRoads to SS4 OpenRoads
 - March – July 2016



Gap Analysis Study

- **Completed by Bentley Systems, Inc.**
 - Determine the road map for INDOT to utilize 3D CAD Models from Design in Construction and Asset Collection
- **Completed and presented September 2016**



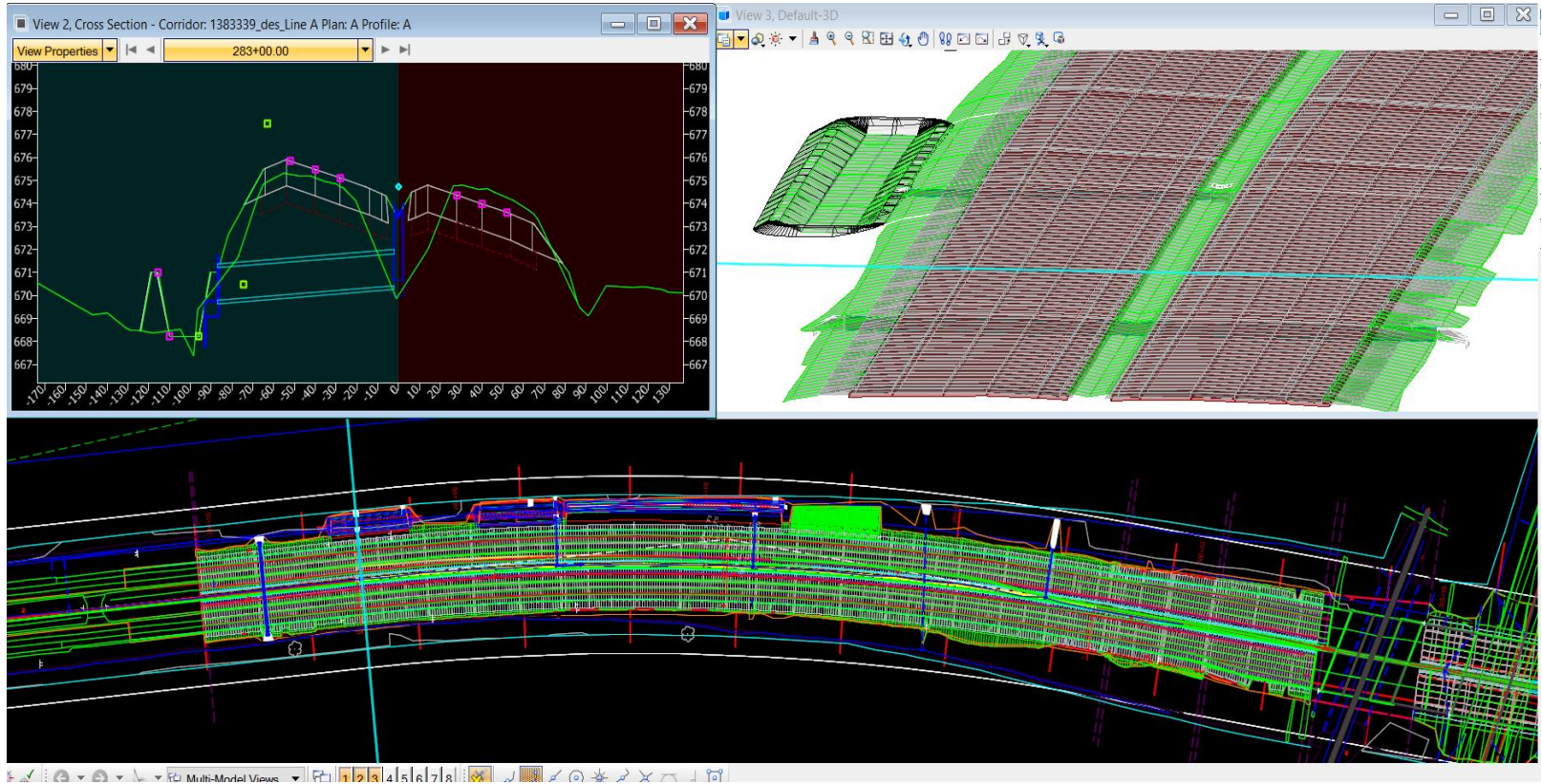
Gap Analysis Study

- **Areas of emphasis:**
 - Automated machine Guidance (AMG)
 - Asset Collection during construction

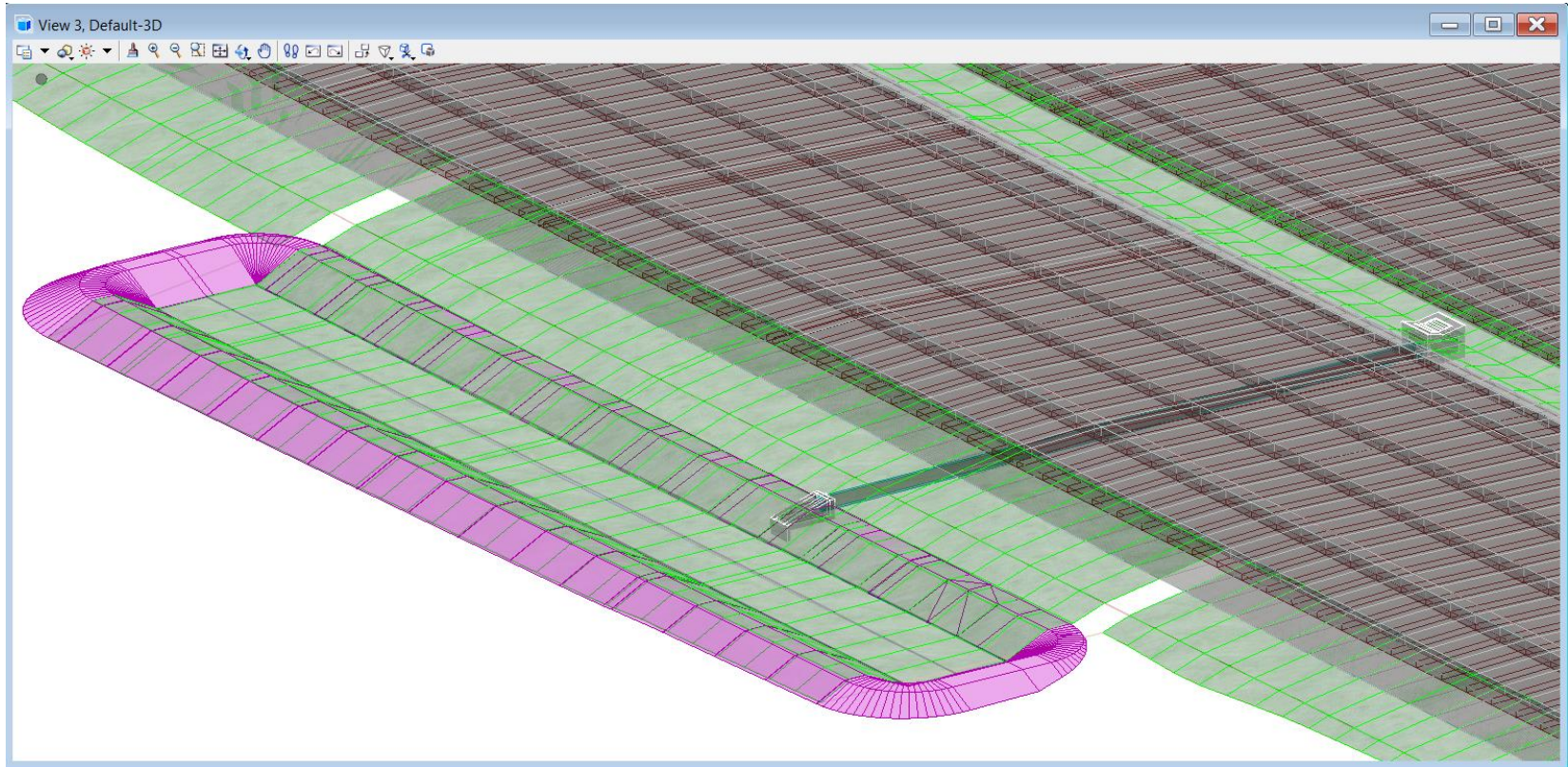


- **Pilot project on I-65 near Lafayette, IN**
 - Designed by consultant in current SS2 CAD platform
 - Bentley converted project files to SS4 OpenRoads platform
 - Provided SS4 design models to the contractor
 - Contractor analyzed the new models and provided feedback

AMG



AMG



AMG

- **Expected Key Benefits**
 - Ability to obtain better bids for construction
 - Save time and money during construction
 - Improved site design
 - Improved safety



AMG

■ Recommendations

- Develop project selection criteria
- Develop QA/QC specifications for 3D Models
- Develop specifications for electronic deliverables
- For AMG projects the construction staff need to be involved early in the design process
- Determine contractor AMG requirements
- Develop an organizational change plan



■ Recommendations

- INDOT currently uses 2D plans for project delivery. It is assumed based on other DOT's and FHWA EDC that the following sequence will be followed:
 - 3D models are created by INDOT's consulting community and internal design staff, but are used to create 2D plans
 - The above 3D models are provided for "information only." The 2D plans are still provided and remain the contract document
 - Long-term, 3D models become the contract document with 2D plans provided with supplemental information
 - Longer-term, a 3D model has all information including those previously provided on 2D plans. 2D plans are not provided

Asset Collection

- **“Experiments”**
 - Drone Imagery for Asset Collection
 - Radio Frequency Identification (RFID) Tags



Drone Imagery

■ Experiment Details

- Can imagery be utilized to collect assets and assist INDOT Construction?
- Scheduling and liability issues prevented the use of a Unmanned Aircraft System (UAS)/drone
- Used handheld camera on an extension pole to take images around the Indiana Government Center complex



Drone Imagery



Drone Imagery



Drone Imagery



Drone Imagery

■ Experiment Recommendations

- Using handheld camera to acquire images is a viable option for collecting small areas
- Control points are necessary to accurately geocoordinate the imagery to real world
- Potential use in calculating areas, volumes



RFID Tags

■ Experiment Details

- Can RFID tags be used to uniquely identify INDOT Assets?
- Future asset inventory verification process?



RFID Tags



RFID Tags

- **Experiment Recommendations**
 - Determine which INDOT asset types are suitable for tagging
 - Determine if the asset owners see a benefit to tagging
 - Conduct a Proof of Capability study on one or two asset types



HP Tablets

■ Details

- Supplied to INDOT Construction Inspectors and Engineers
- Spring of 2016
- Approximately 550 tablets
- HP Elite X2 tablet with Windows 10 operating system



HP Tablets

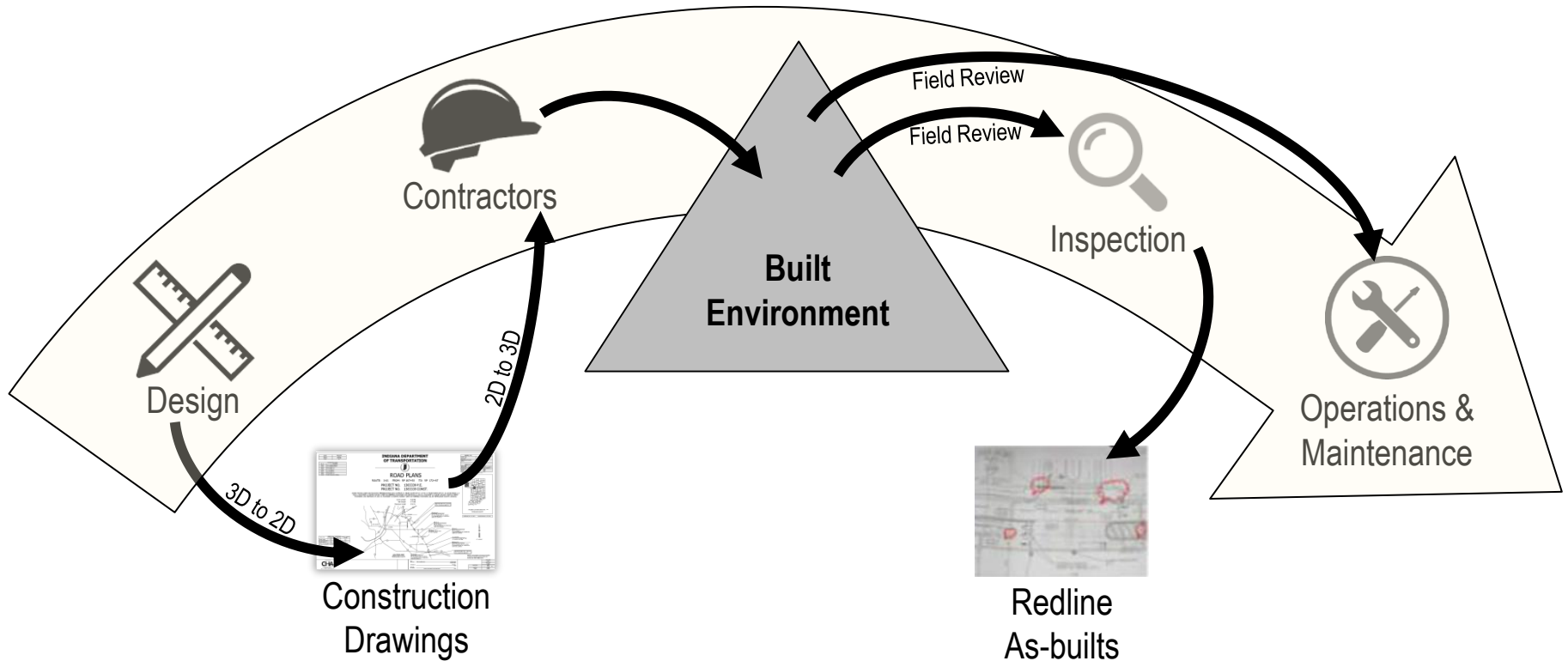
■ Key Benefits

- Office software installed for easy access
- Wi-Fi capable for internet access
- Ability to complete daily tasks in the field
- Access documentation in the field without printing
- Access to Field Assistant and SiteManager applications
- Ability to use the camera for mobile conferencing



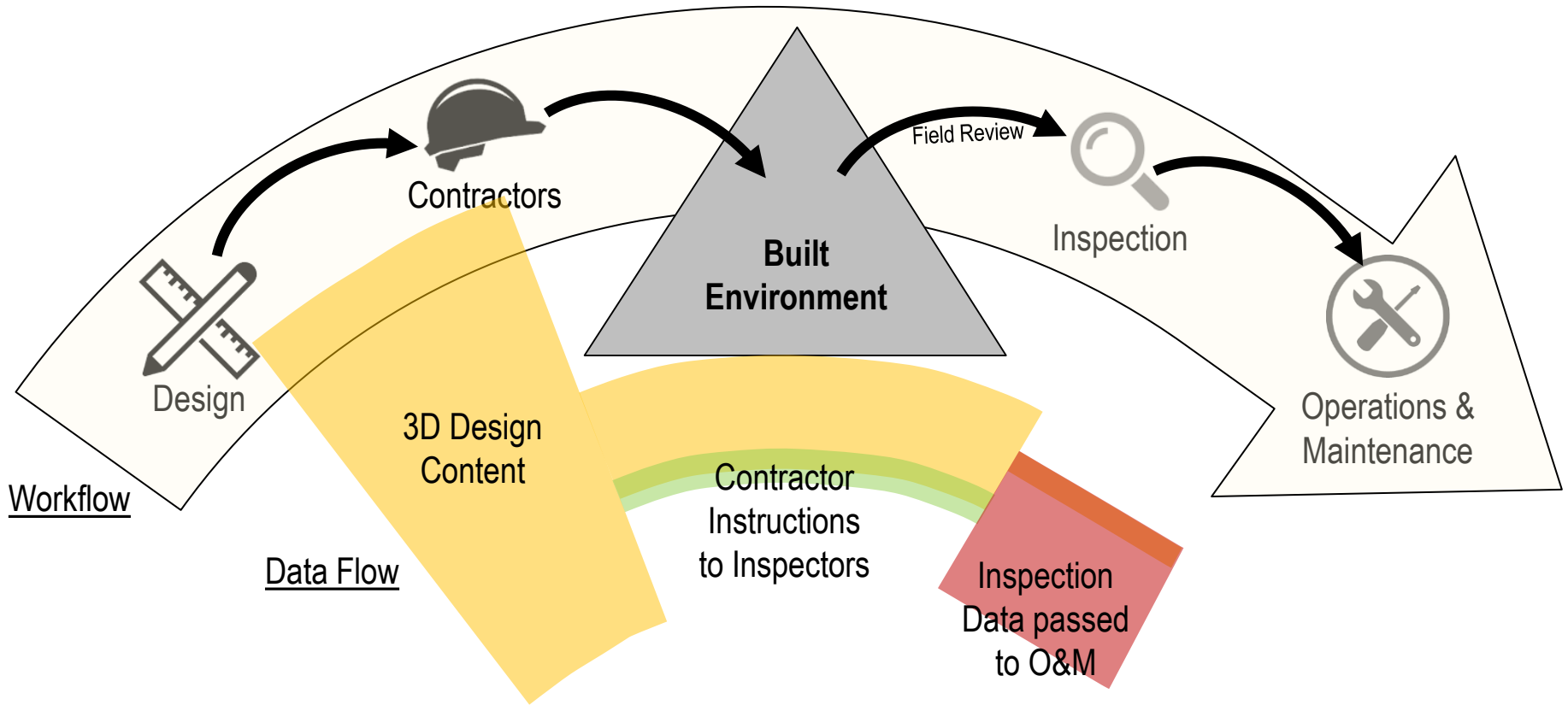
Construction Inspection Application

■ Inspection Problem



Construction Inspection Application

■ Proposal

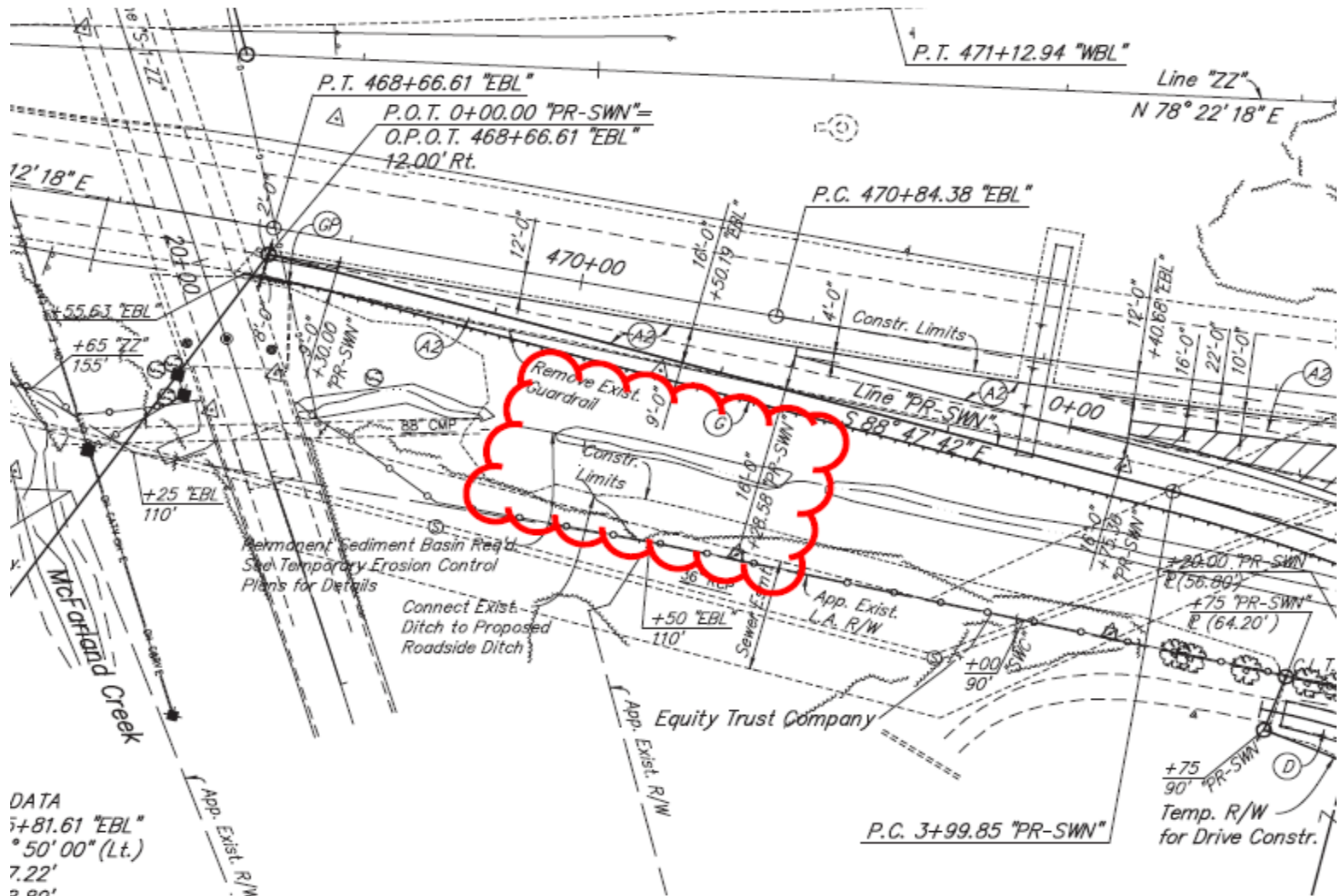


Current 2D Model vs. 3D Model

2D Model	3D Model
Up to Hundreds to Thousands of pages	Limited number of design files
Difficult to find location on plans	GPS on devices will auto locate
Multiple pages and locations for full information on design element	Can have multiple views on one screen
Design Intent/Interpretation can be difficult	Design Intent/Interpretation clearer
Cross Section every 50 ft.	Cross Section every 5 ft.



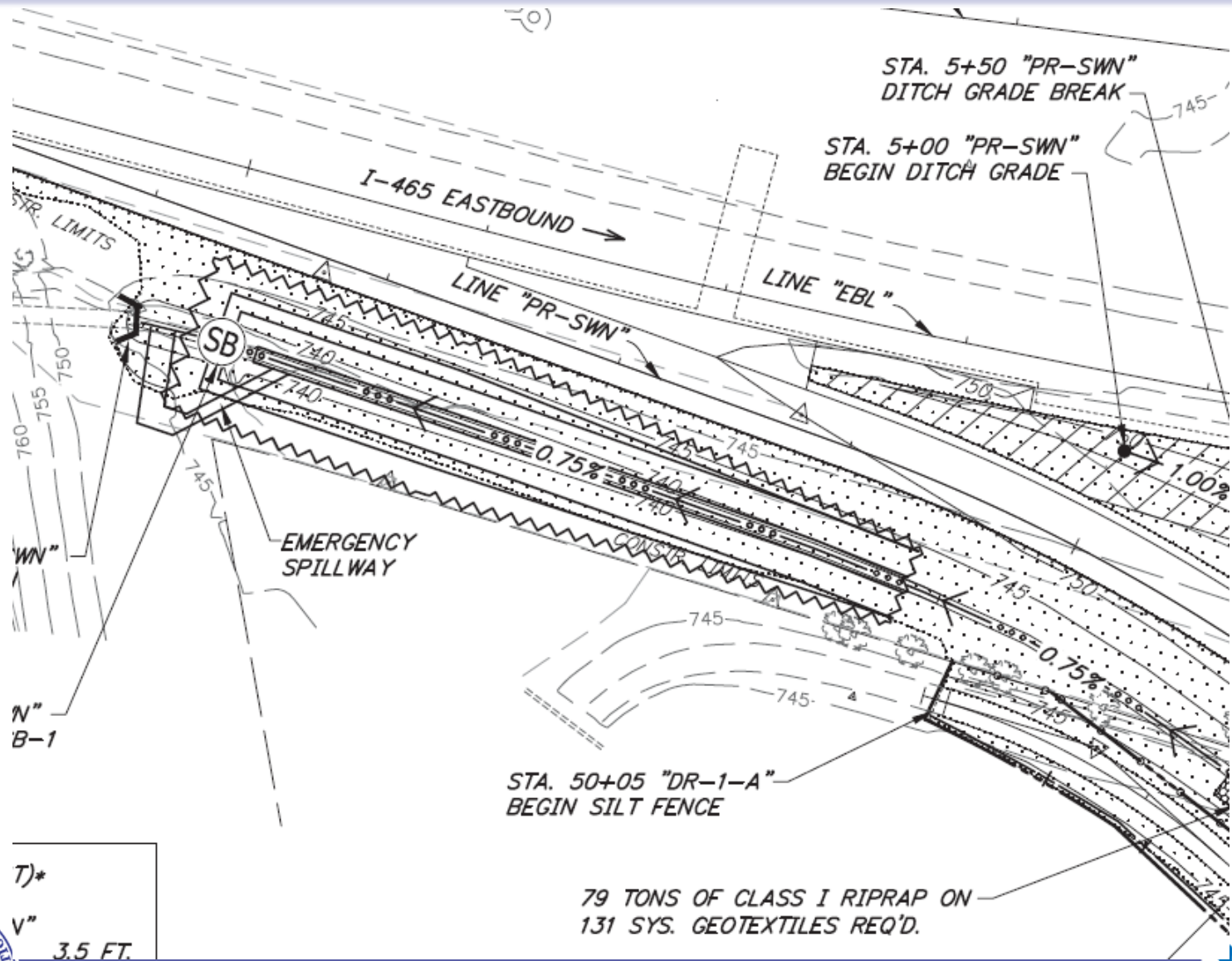
Current 2D Model



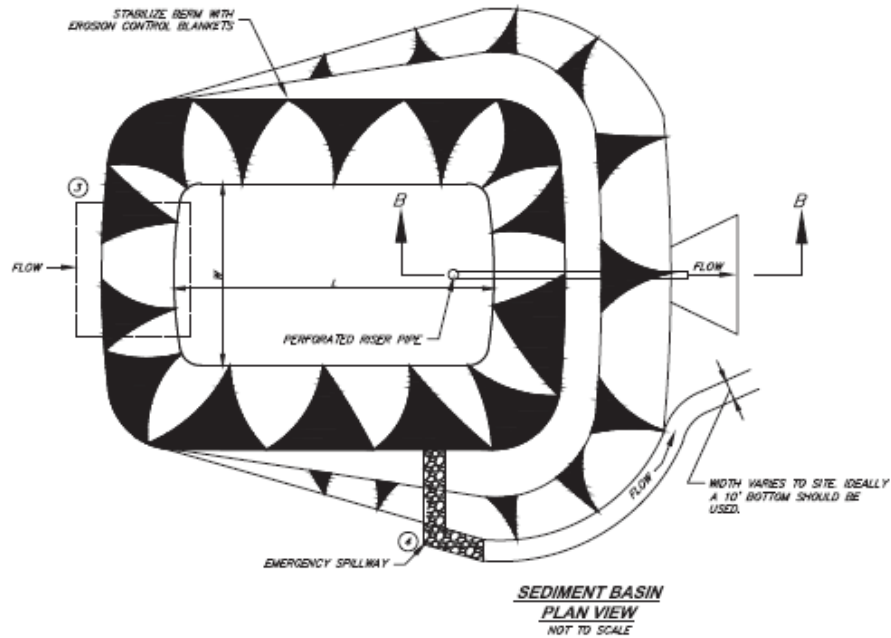
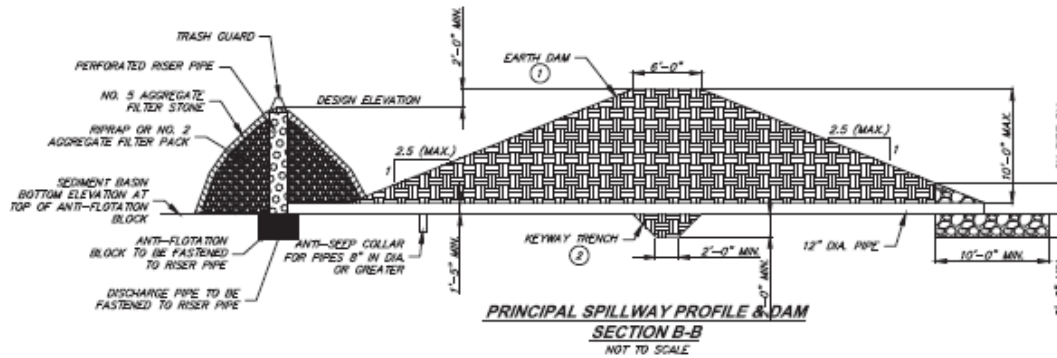
DATA
 5+81.61 "EBL"
 50' 00" (Lt.)
 7.22'
 3.89'
 119.72'
 23'



Current 2D Model

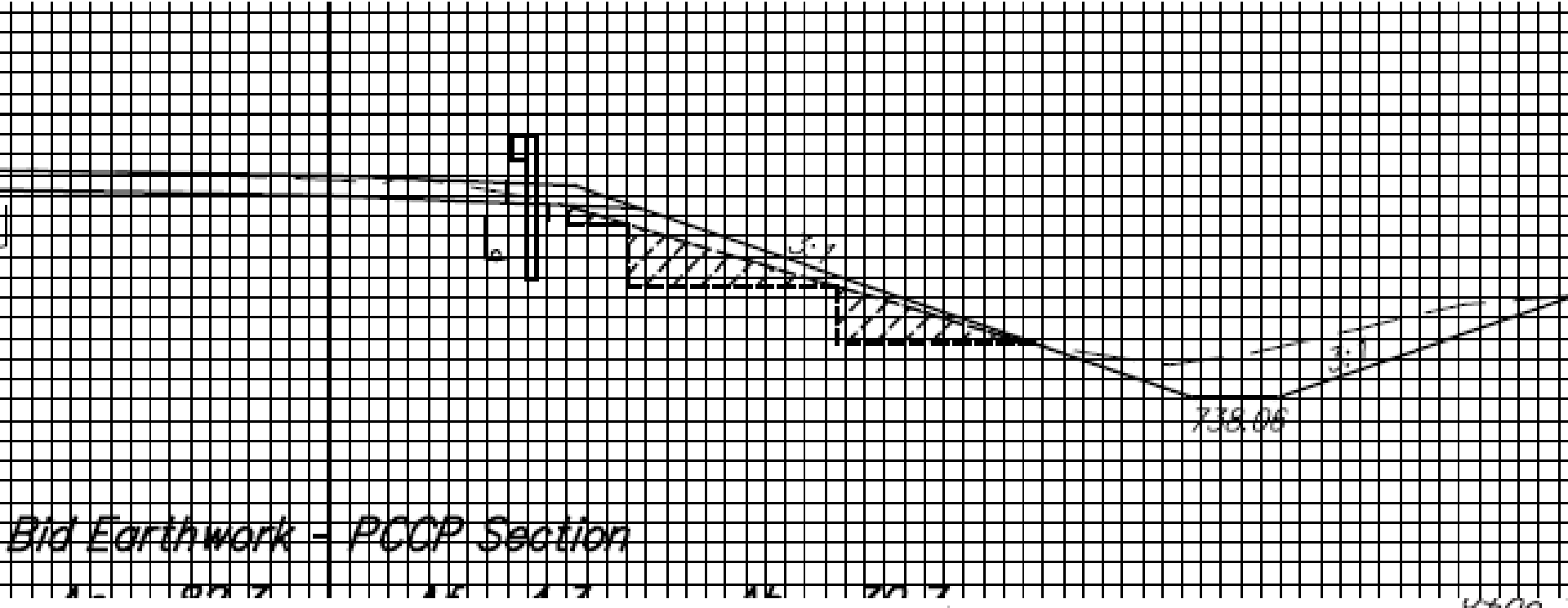


Current 2D Model

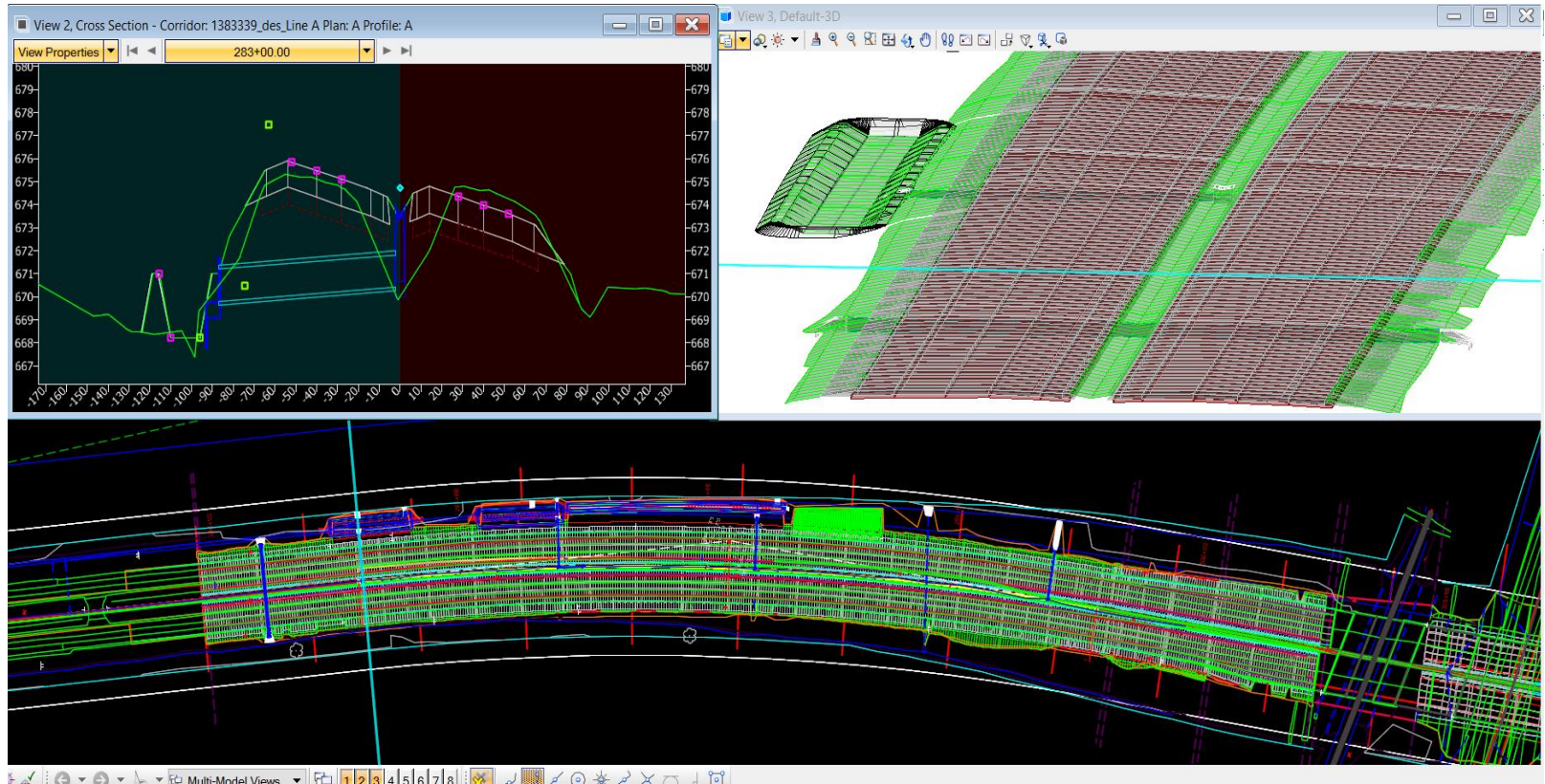


PORT.
THEIR GUIDANCE
FOR WATER TO FLOW INTO
DOWN AND DISPERSE WATER
CHANNEL.

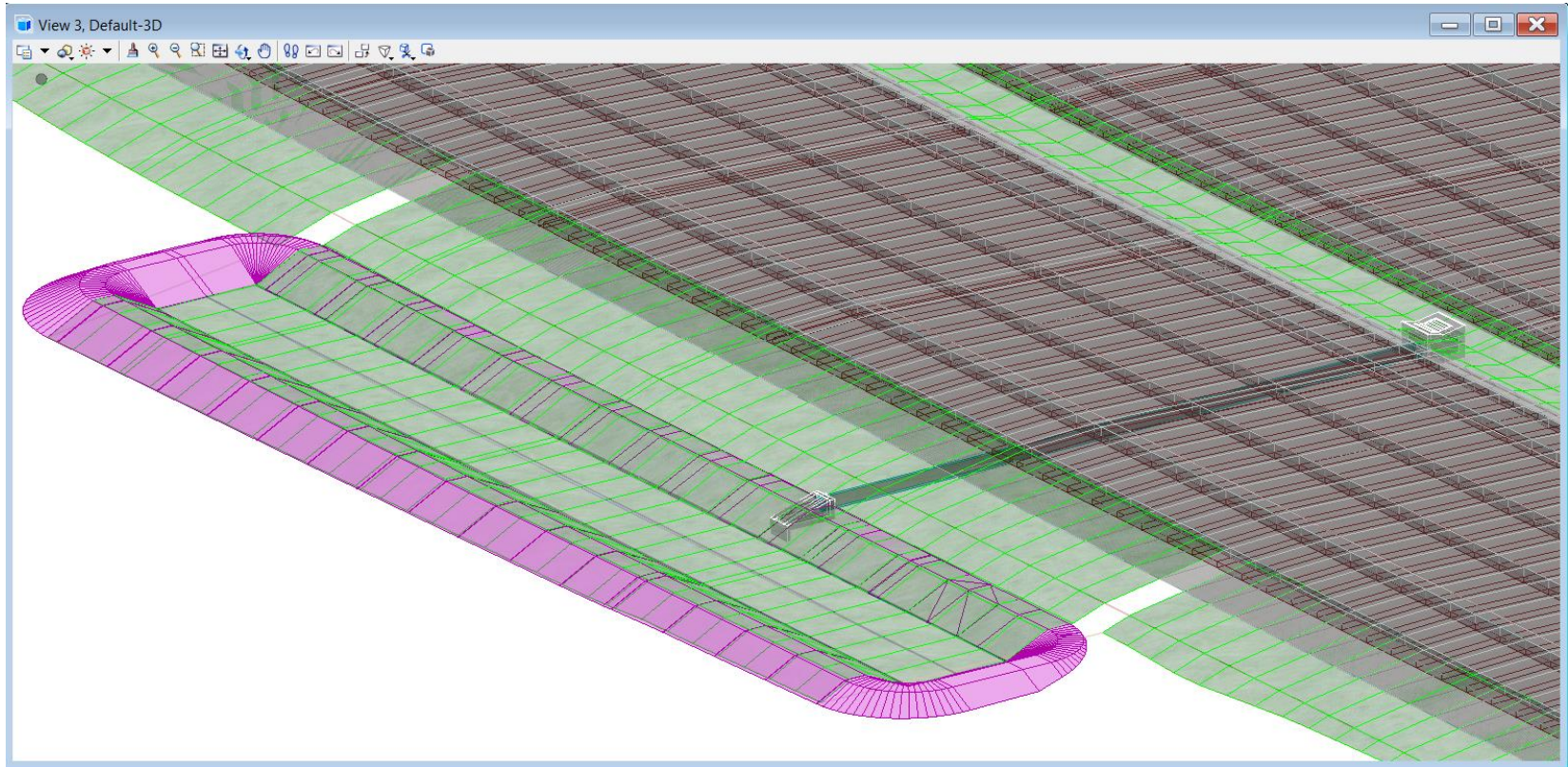
Current 2D Model



3D Model



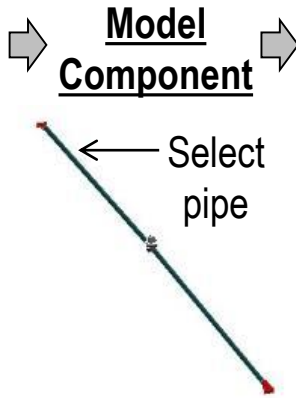
3D Model



Construction Inspection Application

Contractor Instruction

Installing underdrains around stations 370+00 to 420+00



Construction Steps



Trench

Bedding

Lay Pipe

Backfill

Inspection Checklist

- Ensure excavation width no greater than specified
- Ensure unsuitable material removed and replaced
- Check minimum bedding thickness
- Has the bedding material been compacted to standards?
- Has the contractor installed the culvert components to the horizontal & vertical tolerances specified?
- Has the backfill been placed and compacted uniformly in layers?
- Has the side and overlay zone been compacted to the specified requirements?

Inspection Data (INDOT Pay Items)

Field Collect

- Geotextile (718-99153)
- Aggregate Volume (718-52610)

Field Collect

- Date
- Length (715-05203)
- Begin Station
- Begin Offset
- End Station
- End Offset
- Line
- Pipe Size

Field Verify

- Pipe Size
- Begin Elevation

Pass Through

- Begin Elevation
- End Elevation

Asset Mgt

Mobile Inspection Application

Item 206 Lime Stabilized Subgrade

District:		Date:		Project No.:		Co/Rt/Sec:	
Contractor:				Project/District Contacts:			
Reviewed "v"	Specification Conformance Statement	CMS/ CIM	Measurements	Conformance Comments			
	Was the correct soil type stabilized?	206.02/ 189					
	Was specification lime used?	206.02/ 189					
	Did the soil weight at least 100 lbs/ft ³ ?	206.02/ 190					
	Were the limits in 206.03 followed?	206.03/ 190					
	Was the subgrade line and grade properly checked?	206.03/ 237					
	Was the subgrade properly test rolled?	206.03/ 190					
	Was the Contractor lime percentage report accepted by the Project?	206.06/ 192					



Construction Inspection Application

- Help construction engineers/inspectors to mentally link construction activity (received notification), plan asset (physical structures), and pay items (for documentation) and record quantities for identified pay items

Step 1—Plan to place Structure 25



Step 2—Mentally link plans, components, and pay items

Review plans/drawings



Determine components

- Excavate
- Bed
- Place 18" RCP Pipe
- Backfill

Identify and link to pay items



Step 3—Inspect

TEMPORARY CHECK DAM, TRAVERSABLE	75.000
SUBGRADE TREATMENT, TYPE 1A	2,318.000
STRUCTURAL BACKFILL, TYPE 1	204.000
COMPACTED AGGREGATE, NO. 53	4,000.000
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CORED HOLE IN CONCRETE	12.000
PIPE, TYPE 1 CIRCULAR 15 IN	73.000
PIPE, TYPE 1 CIRCULAR 18 IN	150.000
PIPE, TYPE 4 CIRCULAR 4 IN	153,725.000
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Step 4—Measure quantities for pay items—Pipe and Backfill

Construction Inspection Application

■ Inspection Checklist

- Leverage similar capabilities from Field Assistant Application

The image displays two screenshots of the 'Construction Inspection Application' interface. The left screenshot shows a 'Tasks' screen for '052-610RH9002-B Control Panel' with a checklist of 8 items. The right screenshot shows a detailed view of a task, including a 'Test equipment' section with input fields for 'Make', 'Model', 'Serial Number', and 'Expiry Date'.

Step-by-step instructions

Drop down for easy input without errors

Number pads and drop downs for easily entered numerical data

Checksheets are submitted only if all the tasks are completed

Check list

- 1- Confirm vendor test documentation complete and available
- 2- Prove manual operation of isolators, switches and pushbuttons
- 3- Confirm Correct scale and operation of local ammeter if installed
- 4- Confirm local indicators operate correctly and lamps are rated correctly
- 5- Confirm breaker/fuse ratings at feeder source
- 6- Confirm MCC breaker/fuse ratings at feeder source
- 7- Function check control panel, local/remote functions
- 8- Energize panel supplies and check voltage and phase sequence

Test equipment

Make	Model	Serial Number	Expiry Date
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Sign and Submit

Construction Inspection Application

- Improves efficiency of the Construction Inspector in the field
- Easier access to manuals, plans, and project information
- Ability to sign electronic documents remotely
- Provides as-built information including location as part of the work flow
- Transparency—documents available for viewing by all project partners
- Ability to integrate with other core systems such as asset management
- Provides accurate location and asset information
- Provides the ability to create as-built information that can be provided to Programming in the future



e-Construction Future Efforts

- **ProjectWise access for INDOT Construction Inspectors**
- **Pilot construction projects that were designed in the SS4 OpenRoads environment**
- **Develop prototype construction inspection application**



e-Construction Future Efforts

- Quantities from 3D CAD design model
- Provide asset information from the Operations and Maintenance groups to the Planning and Programming group for use in future project determination and funding



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Questions?

