Colonial Pipeline Company - Managing Operational Risk

Topics

- ☑ Background information on Colonial Pipeline
- ☑ Departmental versus Enterprise GIS
- ☑ ArcGIS Pipeline Data Model (APDM) + Geodatabase as foundation for risk based asset management system
- ☑ Role of Risk Assessment in the Pipeline Integrity Management planning process
- ☑ Description of Colonial's Risk Assessment process

Colonial Pipeline Overview

Refined Petroleum Transmission Company

- ~5500 miles of pipeline
- 138 Pump Stations
- 15 Tank Farms
- 265 Terminals

Transports approximately 100 million gallons a day (2.5 million barrels) of jet fuel, diesel, heating oil and automotive fuel

Managing Operational Risk -
Good Data is Required….

Pipeline GIS/Data Management Historically….

- ☑ **Performed on a project by project basis**
- ☑ **Developed at multiple levels within the organization (department, division, location, etc.)**
- ☑ **Typically independent data stores and processes (Data Silos)**
- ☑ **Inconsistent data collection and management**
  - **data duplication**
  - **accuracy differences**
  - **which version of the truth?**
  - **little in the way of standards or guidelines**

Managing Operational Risk

Pipeline GIS/Data Management Today….

- ☑ More centrally controlled within organization
- ☑ Designed to meet enterprise-wide requirements (such as pipeline integrity management)
- ☑ Utilizes industry recognized standards and templates
  - APDM Geodatabase Model
  - data collection and maintenance standards appropriate to the enterprise
  - industry standard communication protocols (SOAP, XML, etc.)
- ☑ Easier integration with other enterprise applications
  - asset management
  - business systems
  - pipeline integrity/risk

Managing Operational Risk

Colonial Uses the Geodatabase and the APDM model as the foundation of their enterprise asset management system

- ☑ **Designed as central repository for all pipeline facility information**
- ☑ **Particular emphasis on pipeline integrity management needs now and in the future**
- ☑ **Data collection at the source – the field – data flows electronically into the database**

Managing Operational Risk

What is the APDM Data Model?

- ☑ ESRI Geodatabase model for …
  - gas and/or liquids, onshore/offshore, gathering, transmission, or distribution pipeline systems
  - focused on pipelines that use stationed position **AND** XY coordinates to locate positions of features on or along the pipeline
- ☑ APDM → ESRI Object Model Template to handle …
  - multiple forms of linear referencing
    - ESRI route and measure technology
  - hierarchical/geographical organization of pipeline features
  - Feature behavior during centerline editing operations
  - Links to external systems – ERP, Document Management, Work Order MS
- ☑ Core Feature/Object Classes
- ☑ Abstract Classes

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APDM Version 4.0

- ☑ Abstract Classes (Core Attributes and Relationships)
  - Centerline Objects, Facility Objects, Online/Offline Objects
  - Response to editing the centerline
  - Auditing feature/object edits
- ☑ Core Classes
  - ControlPoint, StationSeries, AltRefMeasure, Lineloop, Subsystem, SubsystemHierarchy, LineloopHierarchy, Product, OwnerOperator, SubsystemRange, Site, Activity, ActivityHierarchy, ExternalDocument
- ☑ Metadata Classes
  - Formal definition to describe behavior of reference modes
    - Units, Basis, Type
  - Listing and APDM categorization of classes within geodatabase
    - Each class in the APDM will inherit from one of the APDM Abstract Classes
  - Online Locations for Offline Features
    - Listing of offline/online class pairs
    - Listing of calculation methods for determining derivation of online locations
- ☑ Inline History and Auditing

Managing Operational Risk

Compliance and Interoperability

- ☑ The purpose of APDM is to capture the ‘behavior’ of pipeline events, features and objects within a geodatabase object model
- ☑ The purpose of APDM 4.0 abstract, metadata and core classes is to provide a standard for judging APDM compliance to allow true interoperability between vendor applications and data models
- ☑ Colonial is using the Geodatabase, APDM, and the ArcGIS software to build and manage the enterprise GIS that is the foundation for their Pipeline Integrity Management System.

Managing Operational Risk

49 C.F.R. § 195.452 - Pipeline Integrity Management in High Consequence Areas, Sub-Part (e) states:

"An operator must establish an integrity assessment schedule that prioritizes pipeline segments for assessment"

"An operator must base the assessment schedule on all risk factors that reflect the risk conditions on the pipeline segment"

Managing Operational Risk

Sub-Part (e) further states that the factors an operator must consider for risk analysis include, but are not limited to :

- ☑ Results of previous assessments
- ☑ Pipe size, material, and other attributes
- ☑ Operating stress level
- ☑ Leak history, repair history, and cathodic protection history
- ☑ Existing or projected activities in the area (related to 3rd party damage)
- ☑ Local environmental factors that could affect the pipeline (e.g., corrosivity of soil, subsidence, climatic)
- ☑ Geo-technical hazards

Managing Operational Risk

An appropriately designed and implemented pipeline GIS provides the perfect environment for the collection, maintenance, and analysis of data required for pipeline risk assessment

Managing Operational Risk

Colonial Risk Assessment Solution

- ☑ Relative risk ranking model
- ☑ Identify probability of pipe failure factors
- ☑ Identify consequence of pipe failure factors
- ☑ Determine data requirements for each
- ☑ Balance need for data against the cost to obtain data
- ☑ Total probability of failure = sum of all probability factors
- ☑ Total consequence of failure = sum of all consequence factors
- ☑ Total risk = Total probability of failure * Total consequence of failure

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

- ☑ Internal Corrosion
  - number of internal corrosion leaks
  - date of last ILI corrosion inspection
  - date of last hydro test
  - pipe wall thickness
  - SMYS
  - MAOP
  - flow frequency (# of days/year)
  - flow rate

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

- ☑ Equipment Failure
  - number of equipment failure related leaks
  - presence of taps
  - presence of valves

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

- ☑ Stress Corrosion Cracking
  - number of SCC leaks
  - number of SCC indicated ILI anomalies
  - pipe outside diameter
  - pipe wall thickness

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

- ☑ Construction Problems
  - number of buckle leaks
  - pipe outside diameter
  - pipe wall thickness
  - date of last ILI deformation inspection
  - pipe install date (welding, backfill, girth weld indicator)

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

- ☑ Incorrect Operations
  - number of incorrect operation related leaks
  - power and communication backup systems at stations
  - various abnormal operation incidents at stations

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

- ☑ Outside Force
  - number of outside force related leaks
  - type of stream bank protection
  - pipe install date (pipe vintage – resistance to strain)
  - pipe spans
  - areas of exposed pipe
  - water crossings
  - landslide hazard
  - seismic hazard

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

- ☑ Manufacturing Defects
  - number of crack related leaks
  - number of ILI anomalies located on or near seams
  - date of last ILI deformation inspection
  - pipe seam type
  - pipe SMYS (Specified Minimum Yield Strength)
  - pipe install date (pre-1970 ERW)
  - pressure cycling

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

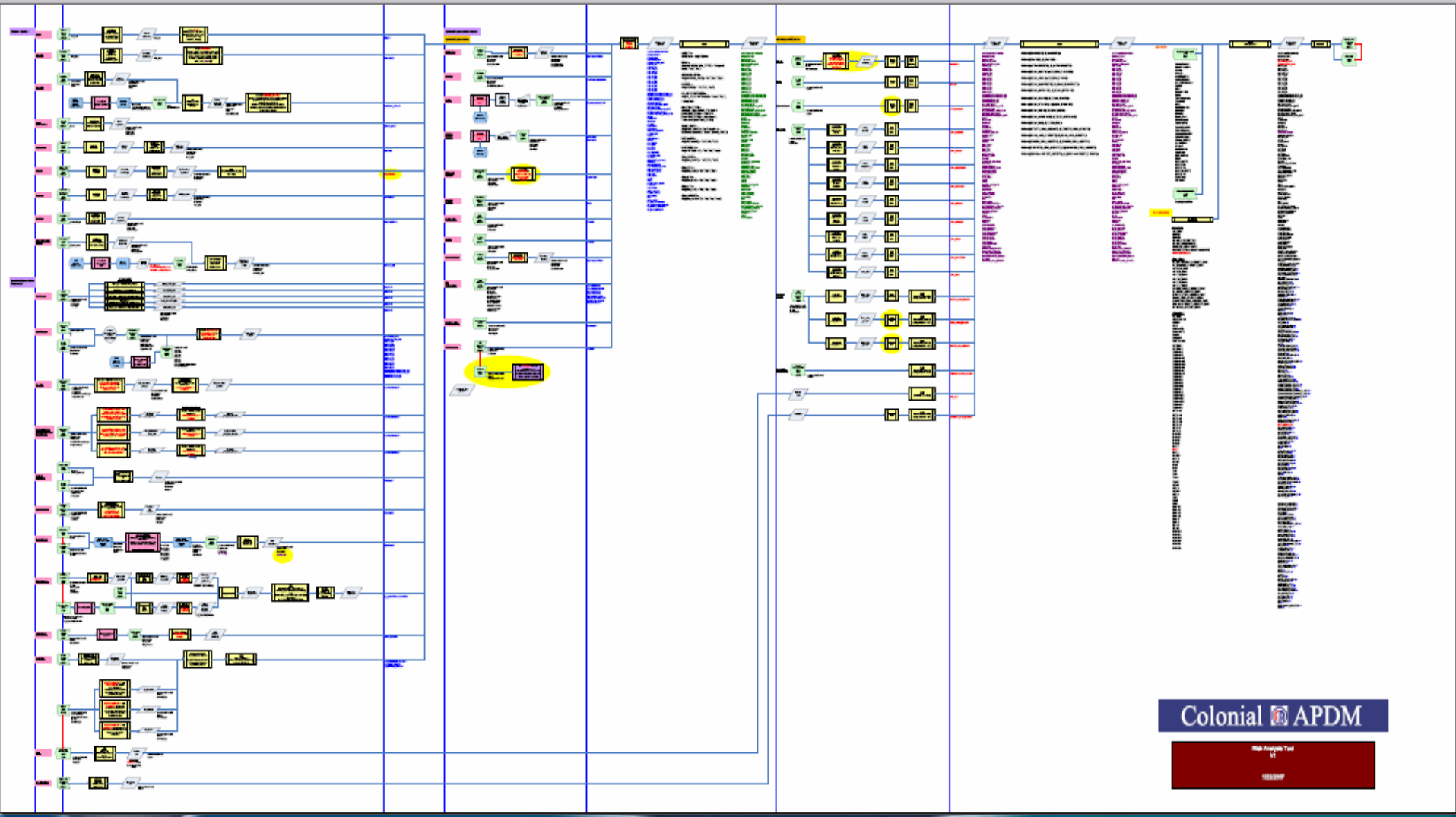
- ☑ External Corrosion
  - number of external corrosion related leaks
  - number of ILI anomalies located on or near seams
  - date of last ILI corrosion inspection
  - pipe wall thickness
  - pipe SMYS (Specified Minimum Yield Strength)
  - presence of casings
  - cathodic protection exception segments
  - density of utility crossings
  - date of last CIS inspection
  - coating age
  - coating type
  - coating condition

Managing Operational Risk

Colonial Risk Assessment – Probability Factors and Data Requirements

- ☑ Third-Party Mechanical Damage
  - number of mechanical damage related leaks
  - number of mechanical damage related ILI anomalies
  - pre-1970 ERW pipe
  - pipe wall thickness
  - pipe outside diameter
  - pipe SMYS
  - pressure cycling
  - aboveground pipe
  - mechanical protection (concrete slabs/matting)
  - concrete coating
  - ROW patrolling interval
  - presence of pipeline markers
  - pipe depth of cover
  - surrounding land use
  - number of road crossings
  - number of water crossings
  - number of unauthorized encroachments
  - onecall density

Colonial Risk Assessment –
Geoprocessing Requirements



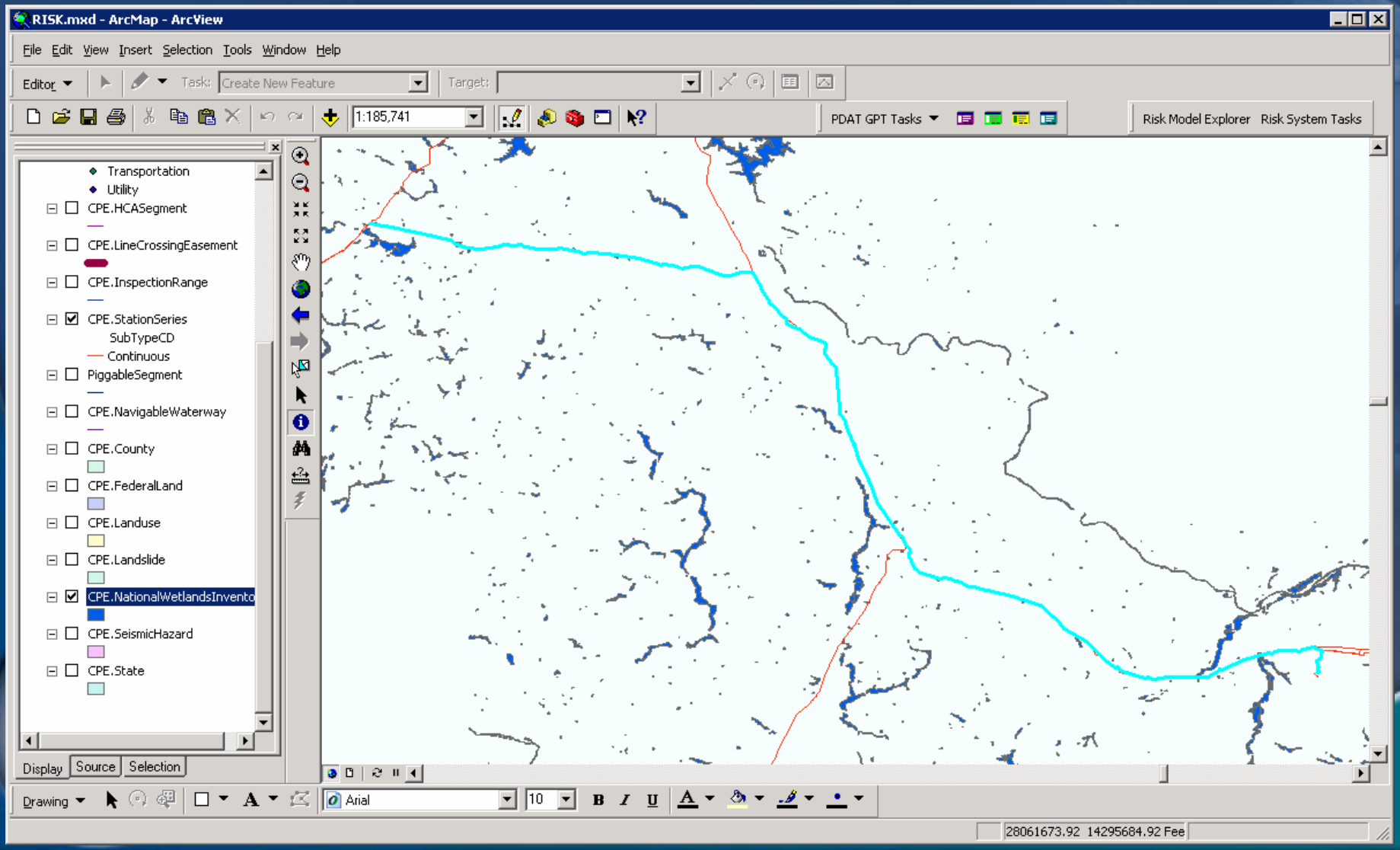
Colonial Risk Assessment – Geoprocessing Requirements

- ☑ Polygon Overlay Analysis
  - seismic hazard
  - landslide hazard
  - county (One call)
  - state (general soils)
  - public lands (600 foot buffer)
  - navigable waterways (600 foot buffer)
  - NWI (600 foot buffer)
  - land use
  - aerial observation flight segment polygons

Colonial Risk Assessment – Geoprocessing Requirements

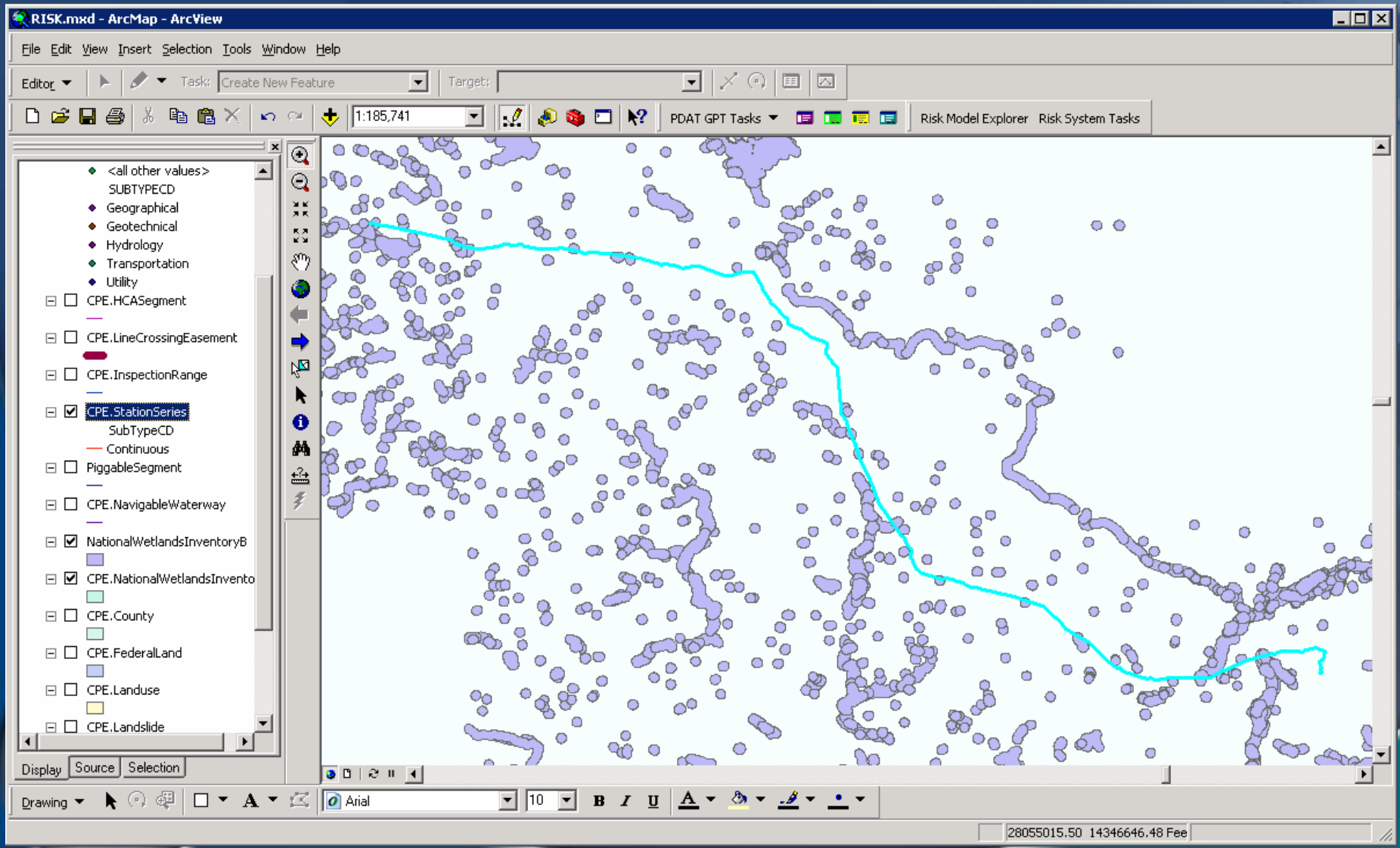
- ☑ Polygon Overlay Analysis
  - overlay polygonal feature on pipe centerline
  - determine entry/exit points of centerline w/polygons
  - generates a stationed, on-centerline linear feature
  - attach specified polygon attributes

Colonial Risk Assessment –
Polygon Overlay Analysis - NWI



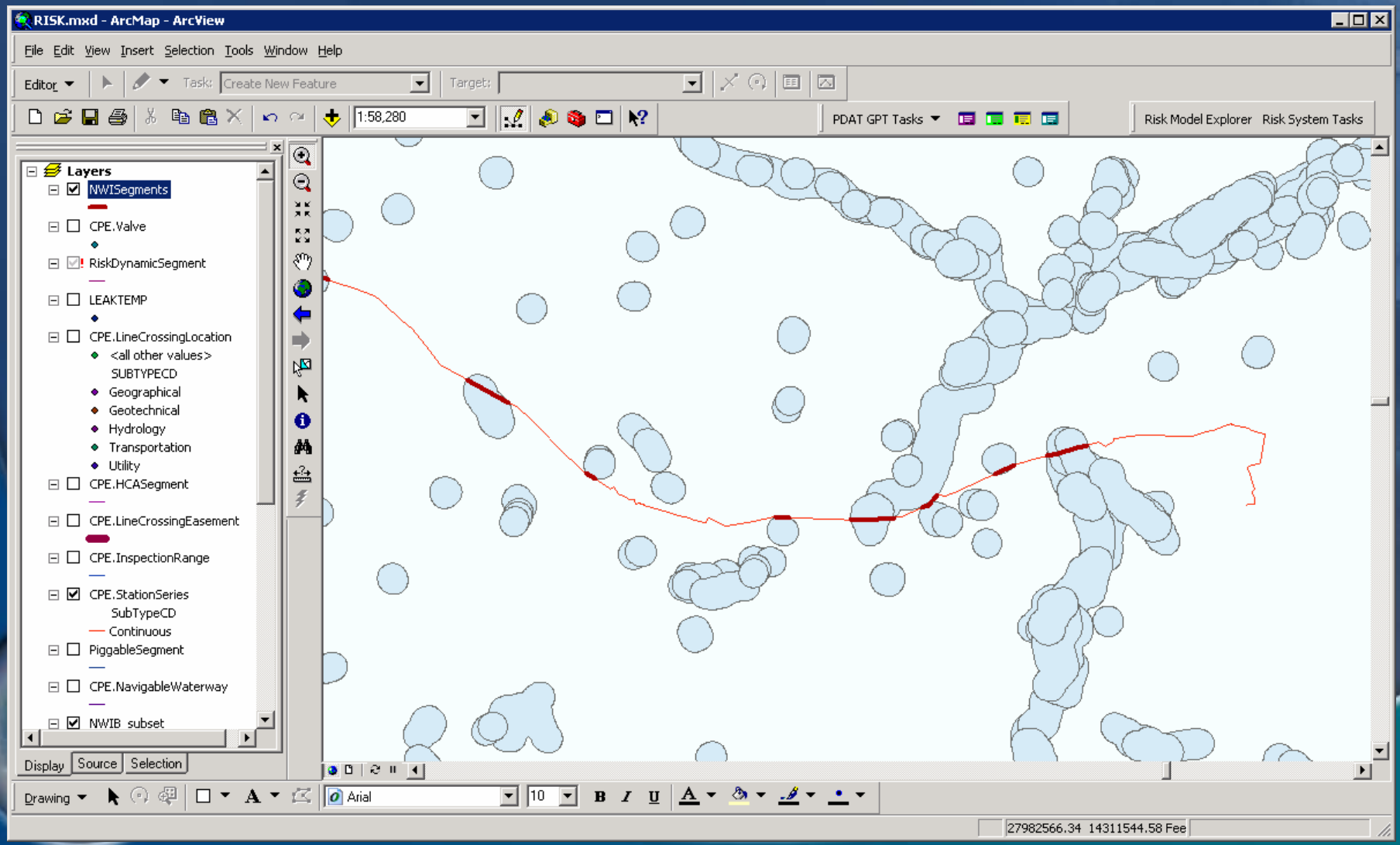
Colonial Risk Assessment –

Polygon Overlay Analysis – NWI Buffer (660 feet)



Colonial Risk Assessment –

Polygon Overlay Analysis – NWI Intersect Segments



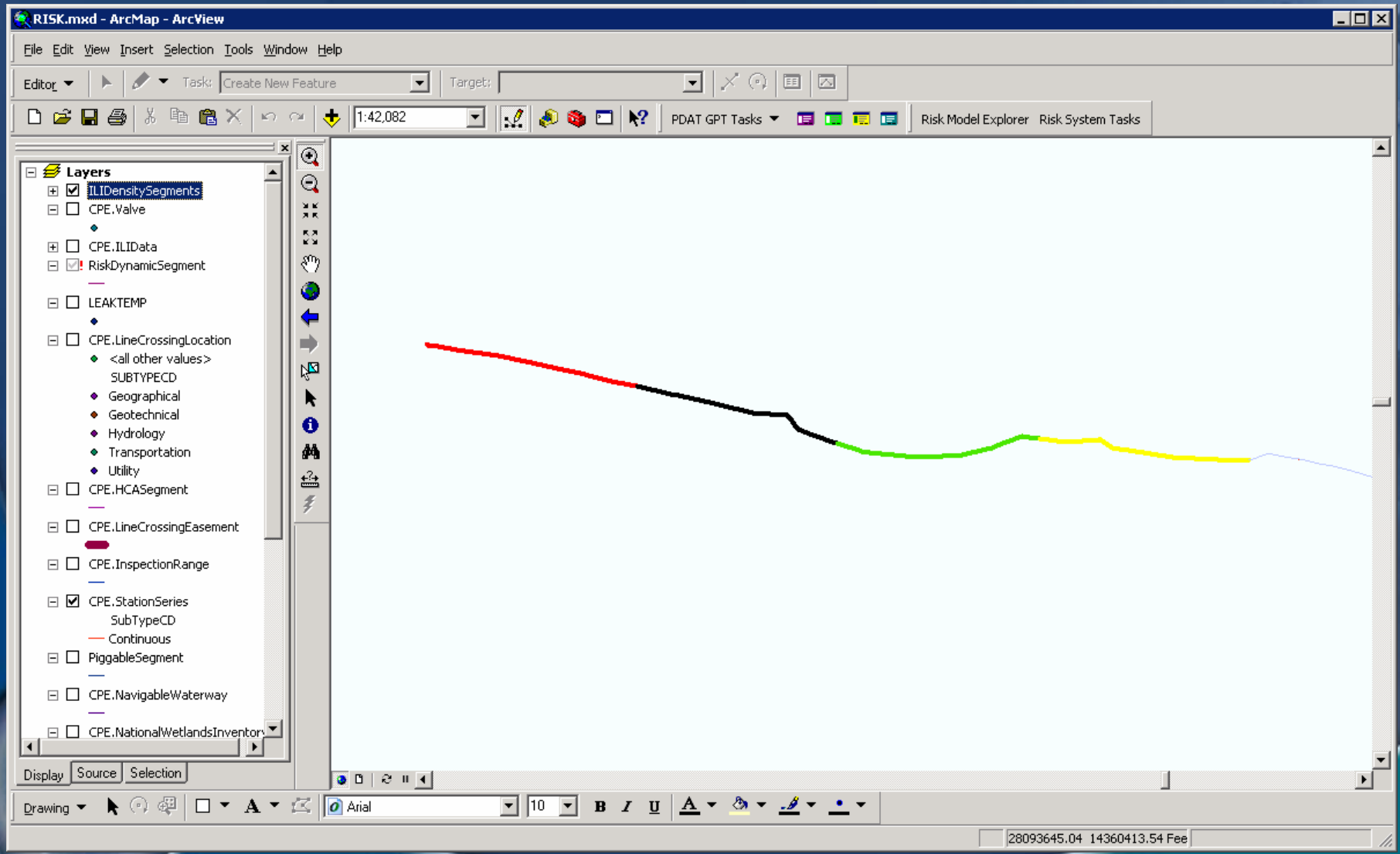
Colonial Risk Assessment –

Geoprocessing Requirements

- ☑ ILI Feature Counts
  - on one mile segments (generate empty segments)
  - corrosion defects
  - damage defects
  - seam defects
  - segment statistics to generate counts
  - input to Dynamic Segmentation

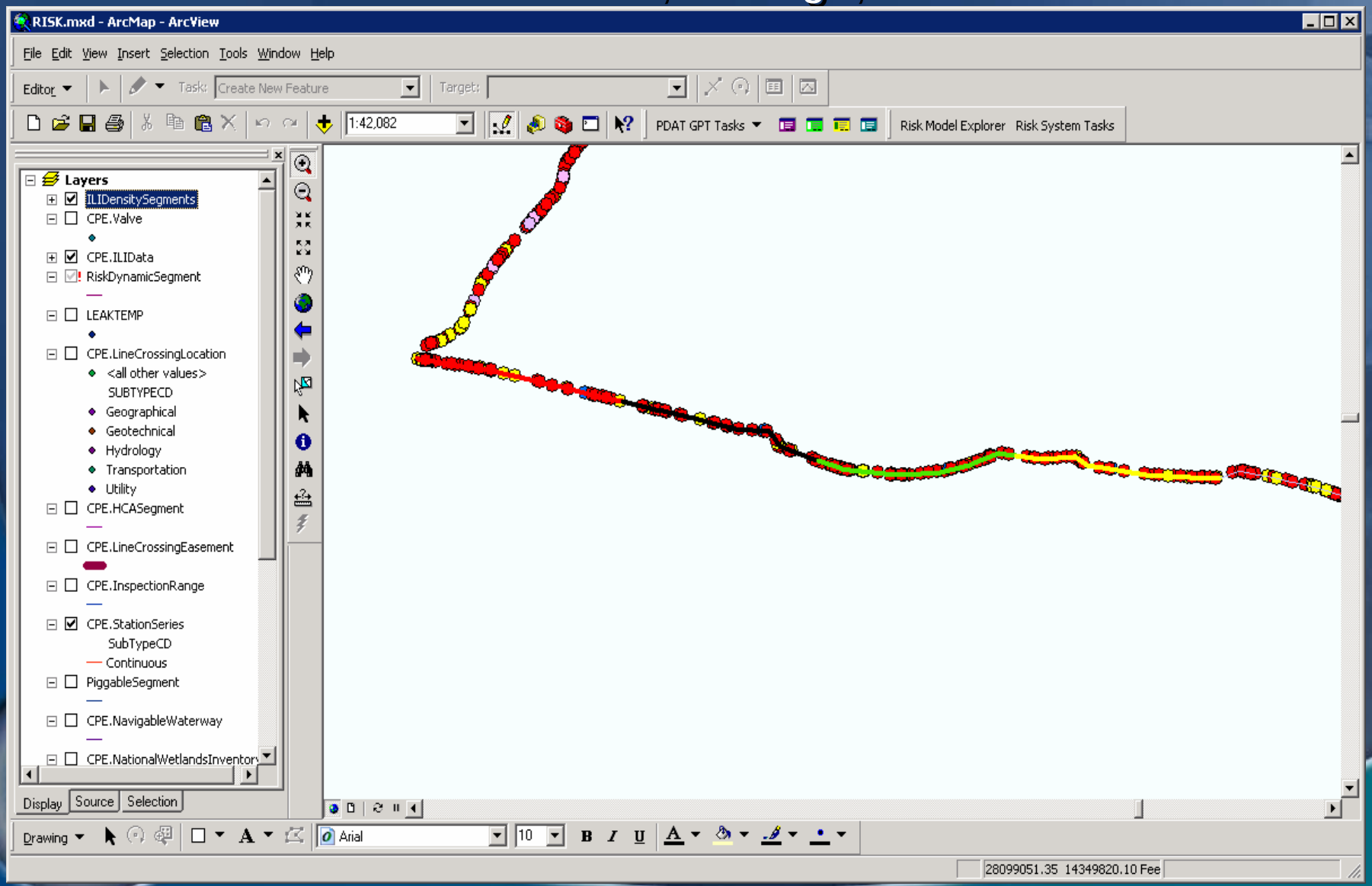
Colonial Risk Assessment –

ILI Feature Counts – One Mile Segments



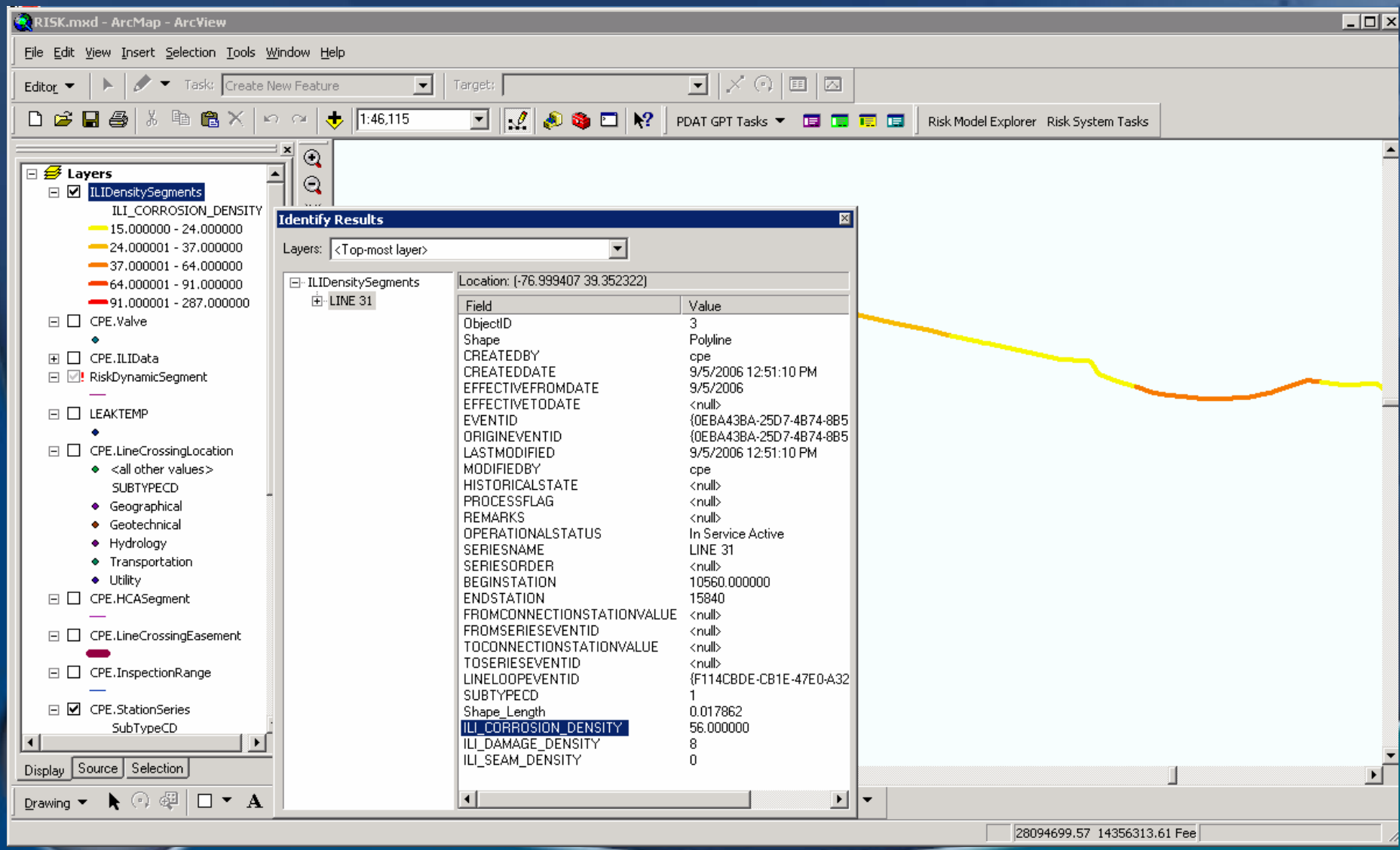
Colonial Risk Assessment –

ILI Feature Counts – Corrosion, Damage, Seam Anomalies



Colonial Risk Assessment –

ILI Anomaly Feature Counts – One Mile Segments

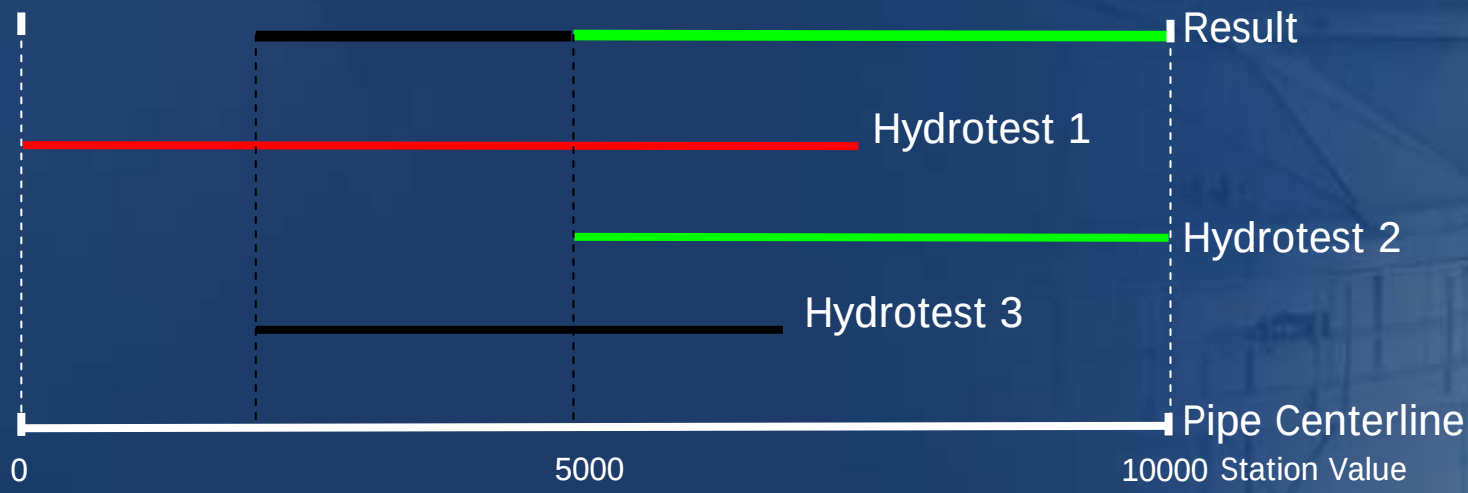


Colonial Risk Assessment – Geoprocessing Requirements

- ☑ Resolve Linear Overlap
  - linear feature with overlap in same pipeline range
  - hydrotests and HCA segments are good examples
  - split at intersections
  - apply selection criteria to determine which overlapping segment to keep
    - most recent test date
    - duration >= 8 hours
    - test pressure > 1.25 X MAOP

Colonial Risk Assessment –
Geoprocessing Requirements

- ☑ Resolve Linear Overlap



Hydrotest 1: Date 3/4/2002, Duration 6 hours, Pressure: 1.5 X MAOP

Hydrotest 2: Date 10/9/2004, Duration 12 hours, Pressure: 2 X MAOP

Hydrotest 3: Date 12/21/2003, Duration 8 hours, Pressure: 1.5 X MAOP

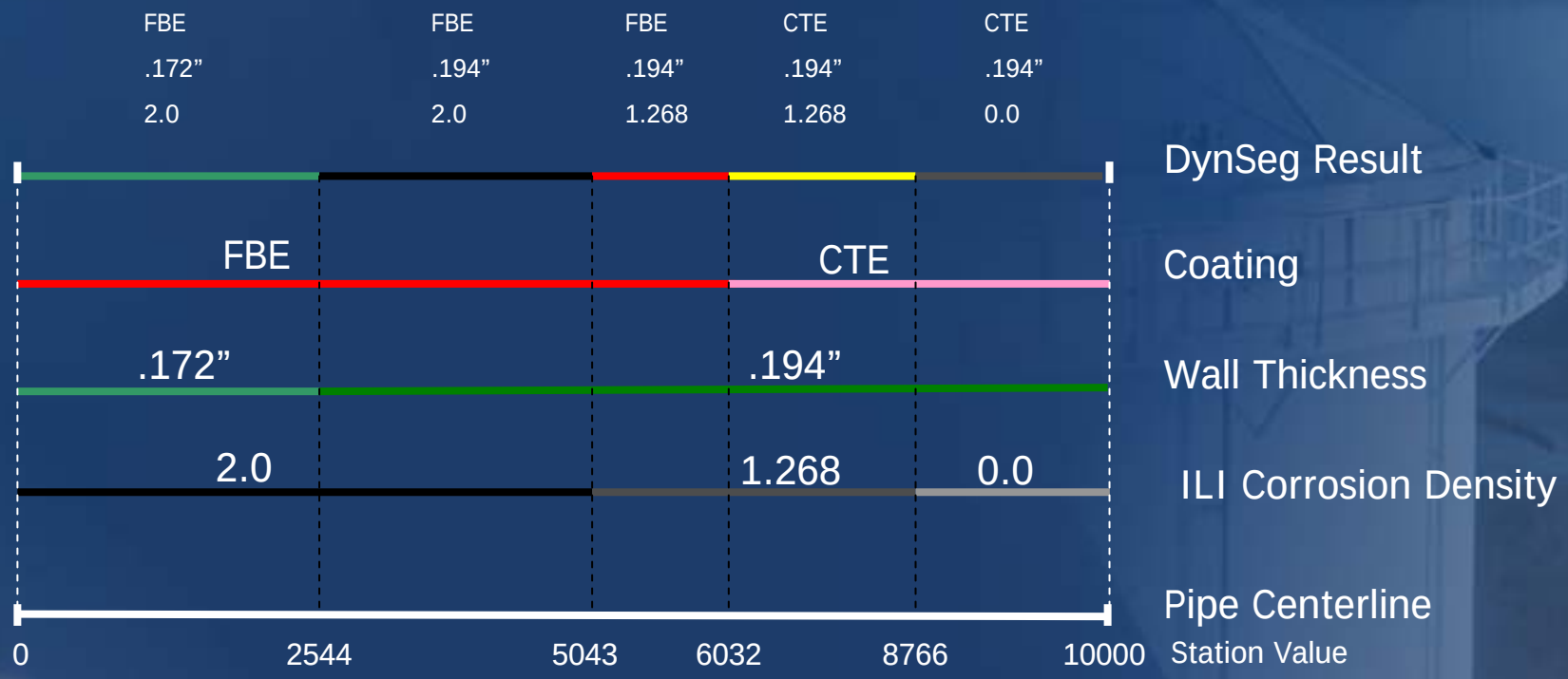
Colonial Risk Assessment – Geoprocessing Requirements

- ☑ Dynamic Segmentation
  - break at any change in attribute
  - highest resolution of the input data

Colonial Risk Assessment –

Geoprocessing Requirements

- ☑ Dynamic Segmentation

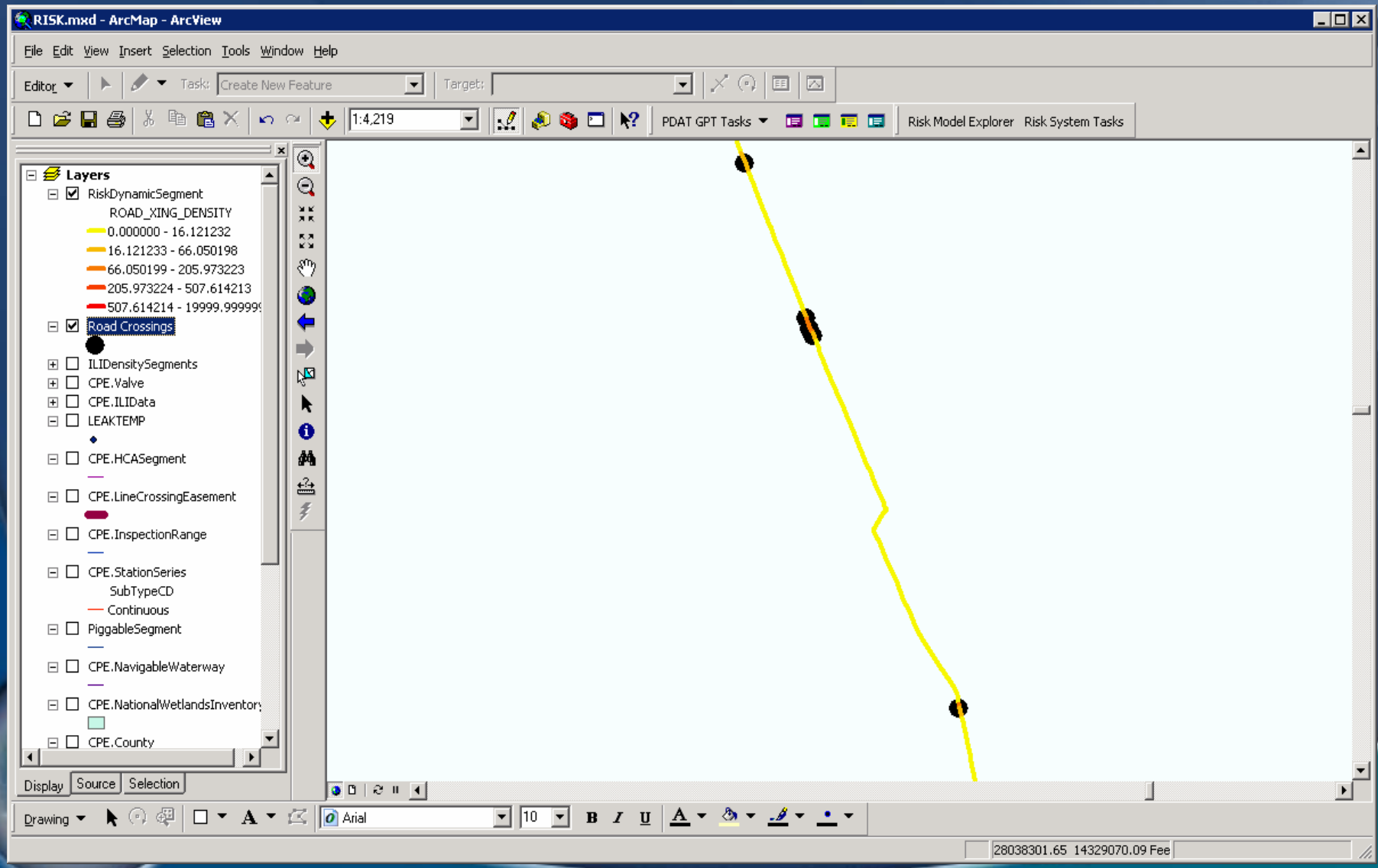


Colonial Risk Assessment – Geoprocessing Requirements

- ☑ Generate point densities on segments resulting from Dynamic Segmentation
  - leaks by type
  - pipeline markers
  - valves
  - pipe attachments (taps)
  - line crossing by type
  - unauthorized encroachments

Colonial Risk Assessment –

DynSeg Point Densities – Road Crossings



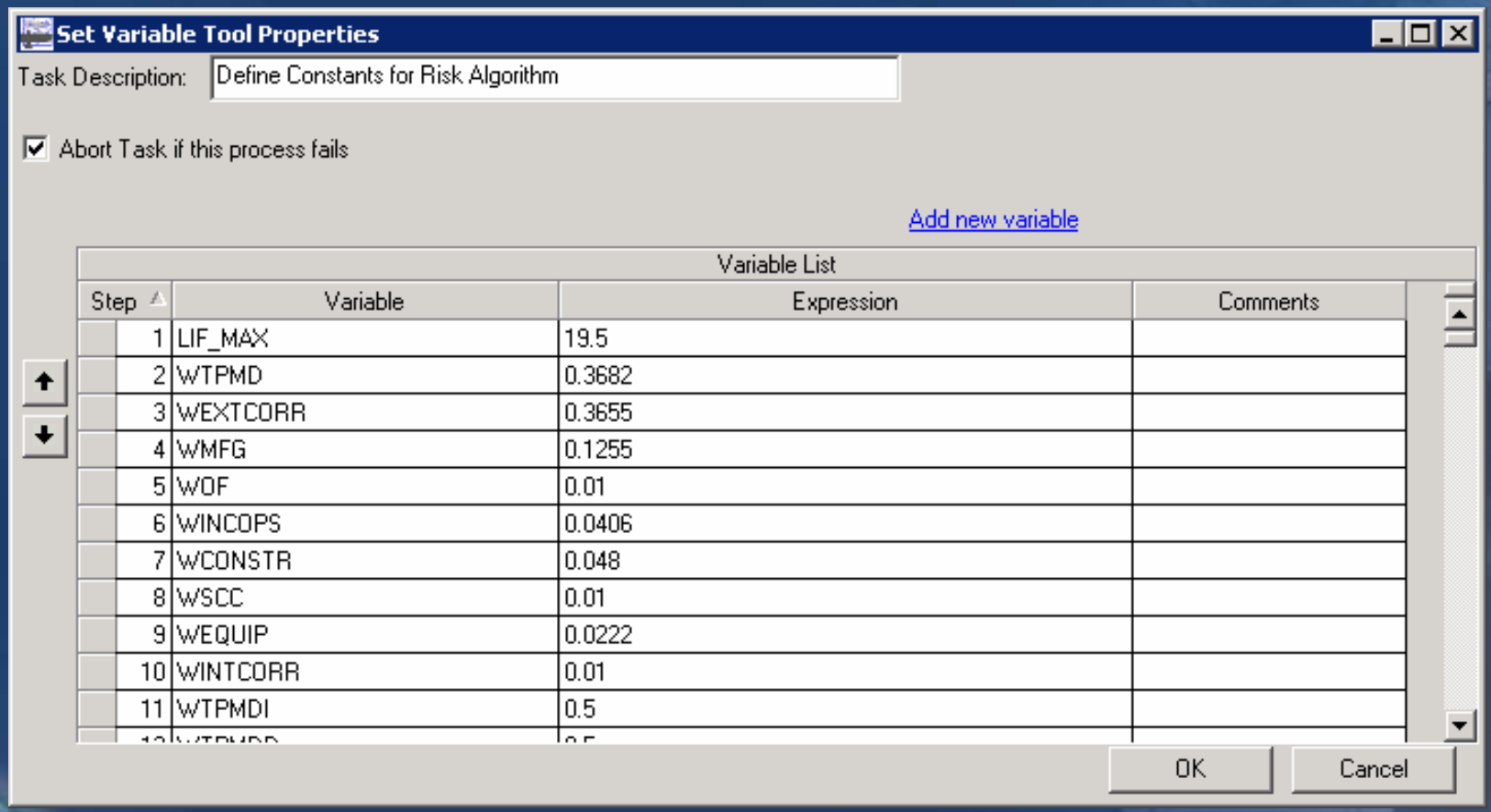
Colonial Risk Assessment –

Set Constants and Parameters

- ☑ Global variables utilized in algorithm set in one location (isolated from algorithm)
- ☑ Numerous “Max” values from Dynamic Segmentation results
  - abnormal operations variables
  - one call density
  - unauthorized encroachments
  - crossing densities

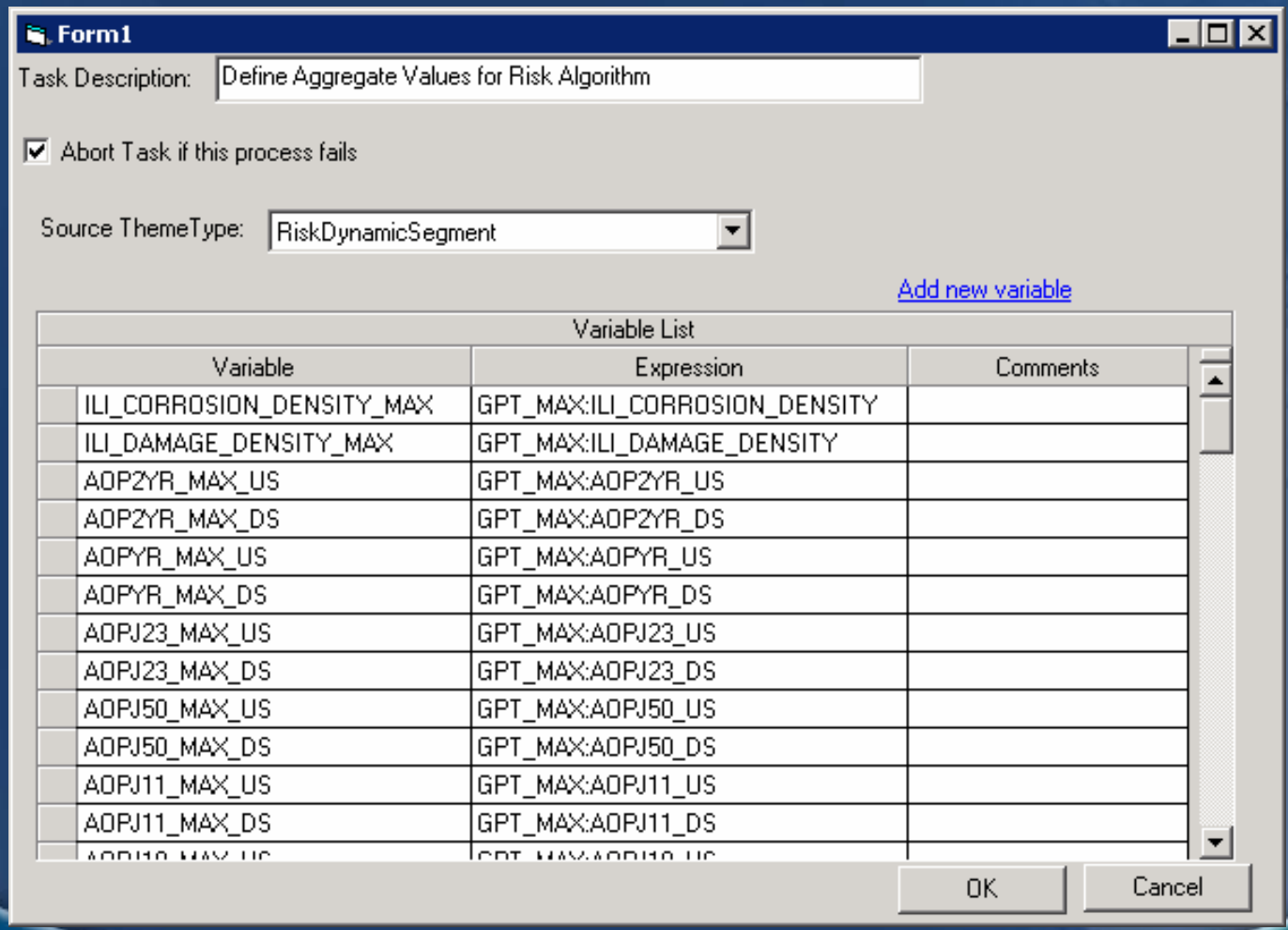
Colonial Risk Assessment –

Setting Global Variables



Colonial Risk Assessment –

Setting “Maximum” Variables



Colonial Risk Assessment –

"Lookup" of Risk Weighting Values

- ☑ Translate variable values to weighting values
- ☑ String variables – examples
  - external coating type
  - bank protection quality
- ☑ Numeric variables (range lookups) – examples
  - number of years since last CIS survey
  - depth of cover

Colonial Risk Assessment –
Lookup – Risk Weighting Values

Attributes of CPE.RiskDimensionOne

OBJECTID*	EVENTID	LOOKUPNAME	MEMBERVALUE	RISKVALUE	MEMBERTYPE
214	{4FAD8B70-91AC-41B3-B100-44A10299AFCA}	AboveGround	*ISNULL*	10	String
191	{32416B27-52D5-3F45-E147-74D0BFEC24BA}	AboveGround	No	0	String
89	{6A9953CE-3BDF-1846-CEF7-77A4F7C4EED9}	AboveGround	Unknown	10	String
122	{8ED6EEA0-E45B-F24C-2797-7BA94BFD16BD}	AboveGround	Yes	10	String
207	{700089F9-4BDB-48B9-AC1F-E9C58A25C835}	BankProtection	*ISNULL*	10	String
91	{BB250F90-9EA2-B041-995D-D1938E284D1B}	BankProtection	Excellent	2	String
117	{5E8BE574-CCAF-024B-43C2-209316639637}	BankProtection	Fair	6	String
12	{8F426D1C-CE87-DB4E-10E9-9C110B1C3BE6}	BankProtection	Good	4	String
164	{1BB04A1F-861F-D741-5615-598E84A7E3F7}	BankProtection	N/A	0	String
80	{BB11DDA0-9E16-A24B-3D5B-B750E8137449}	BankProtection	None	10	String
98	{D17C4FFE-EB25-2949-0715-5057C290478E}	BankProtection	Poor	8	String
29	{6067789D-9CCA-BE4B-03F7-7B5C7BF243FB}	BankProtection	Unknown	10	String
209	{4E22CABA-1D86-40F8-9676-987AAF993869}	Casing	*ISNULL*	0	String
160	{8AAB237E-B898-C04D-55A0-03178ACC70BF}	Casing	No	0	String
171	{39860ECD-33F2-564C-4FB5-5660914E6C51}	Casing	Yes	10	String
136	{3AFCC0B1-E23C-B346-486E-EF1017EDEC5D}	CisAge	0	1	Numeric
60	{C1D395AB-DD46-3F4E-EB41-19C090010F82}	CisAge	1	1.05	Numeric
111	{70C8A417-45C8-924D-96C7-78ABB90B9B5D}	CisAge	10	1.5	Numeric
32	{F6B58C21-73F0-D140-EA04-4F5E27E133A4}	CisAge	2	1.1	Numeric
139	{A0621AB2-1612-9A48-E10A-A374A49B9233}	CisAge	3	1.15	Numeric
192	{79C863A2-6F27-154A-C91C-C35D66F32C87}	CisAge	4	1.2	Numeric

Record: 2 Show: All Selected Records (0 out of 284 Selected.) Options

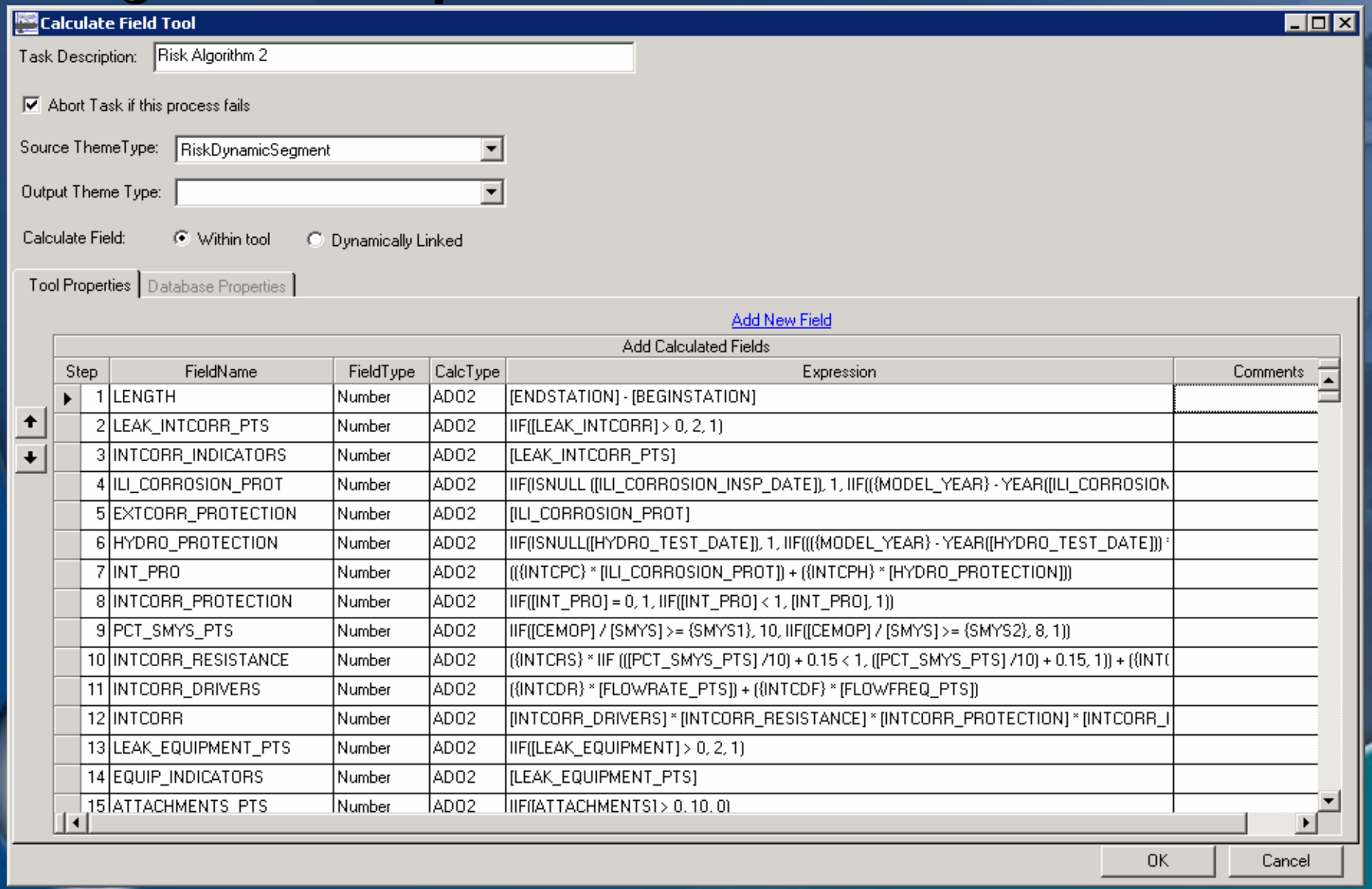
Colonial Risk Assessment –

Algorithm Expressions

- ☑ Utilize enhanced “CalcField” tool
- ☑ Calculates multiple fields simultaneously
- ☑ Dynamically adds the field to the output theme if necessary
- ☑ Dynamically replaces VBA or Calc expressions with variables created elsewhere
- ☑ Ultra-fast ADO2 calculation method

Colonial Risk Assessment –

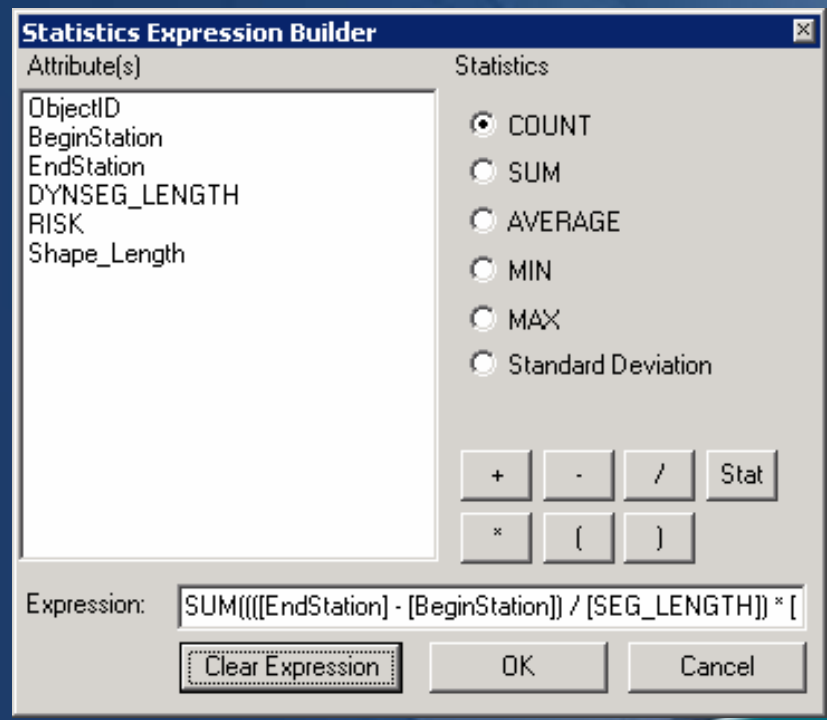
Algorithm Expressions - CalcField



Colonial Risk Assessment –

Results Rollup

- Summarize risk results to various levels
  - 1,000 foot segments
  - piggable segments
  - HCA Segments
- Define rollup expression
  - Length Weighted formula
  - SUM((([EndStation] - [BeginStation]) / [SEG_LENGTH]) * [RISK])



Colonial Risk Assessment –

Geoprocessing Requirements

- ☑ Length Weighted Risk

  SUM((([EndStation] - [BeginStation]) / [SEG_LENGTH]) * [RISK])

Length Weighted Risk:

1318.52

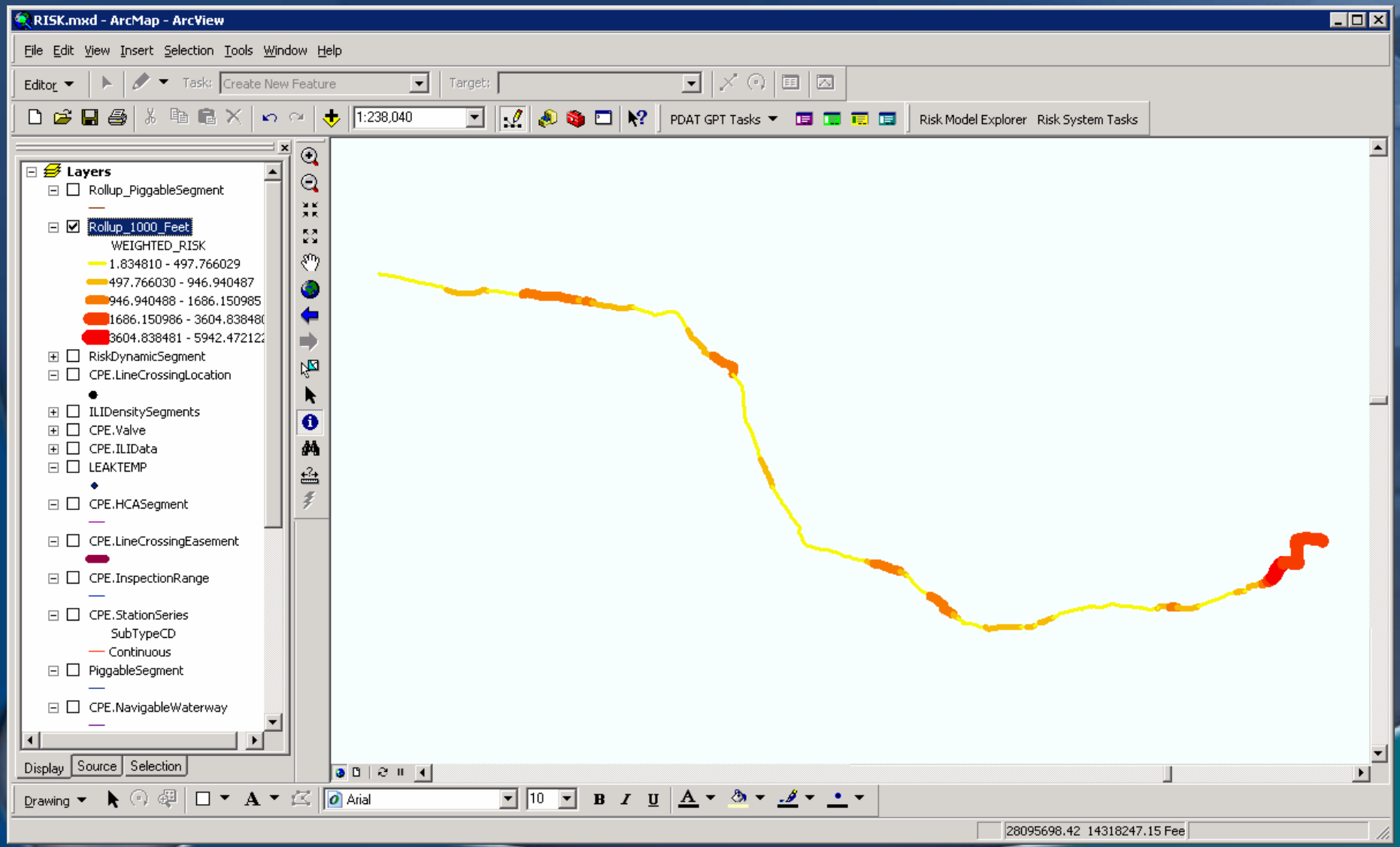
1,000 Foot Segment

DynSeg Result

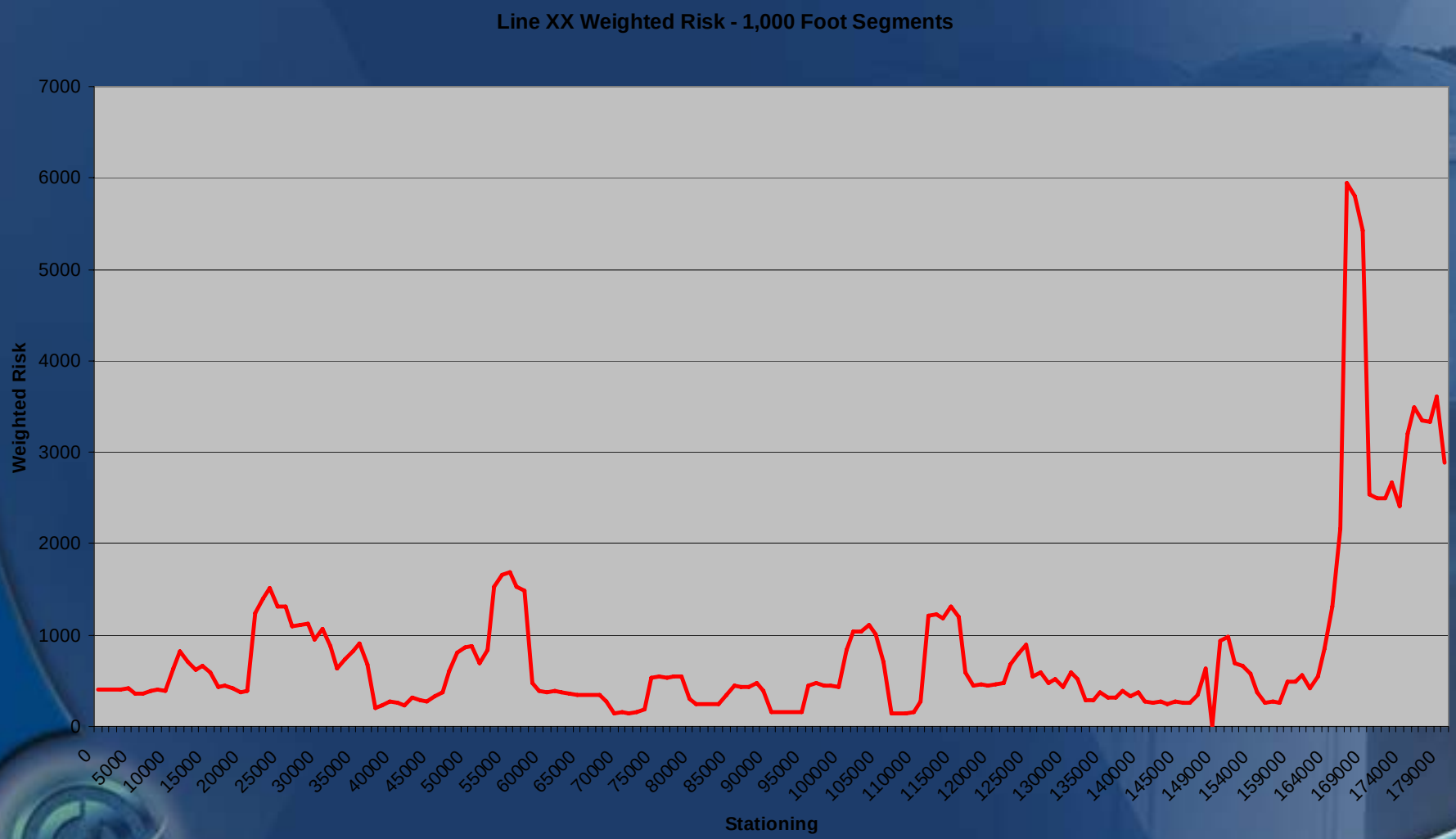
Station Value

Colonial Risk Assessment –

Symbolized Risk Results – 1,000 foot segments



Colonial Risk Assessment – Results



Colonial Risk Assessment – Results

Average and Length Weighted Risk

by 1,000 Foot Segment

SERIESNAME	BEGINSTATION	ENDSTATION	AVG RISK	WEIGHTED RISK
LINE XX				
	0	1000	380.518599918791	399.896473481664
	1000	2000	380.458971036278	401.623906585802
	2000	3000	380.545618612975	400.170782022668
	3000	4000	380.570382180798	408.135093648418
	4000	5000	380.570375917737	413.006389419658
	5000	6000	356.97319033288	362.078643656187
	6000	7000	356.282841887101	366.323380741634
	7000	8000	366.027313613528	383.811765476527

Colonial Risk Assessment – Results

Top Scoring Segments - Length Weighted Risk

by 1,000 Foot Segment

SERIESNAME	BEGINSTATION	ENDSTATION	WEIGHTED RISK
LINE XX			
	166000	167000	5942.47212168976
	167000	168000	5801.88657918426
	168000	169000	5424.15217823648
	178000	179000	3604.83847961627
	175000	176000	3492.81162189647
	176000	177000	3346.19844133042
	177000	178000	3330.99466171044
	174000	175000	3207.29611642876
	179000	179366	2892.46814270678
	172000	173000	2663.74911316636
	169000	170000	2545.06563665665
	170000	171000	2496.84120520078