Emergency Flow Restriction Device (EFRD)

Adequacy Evaluation

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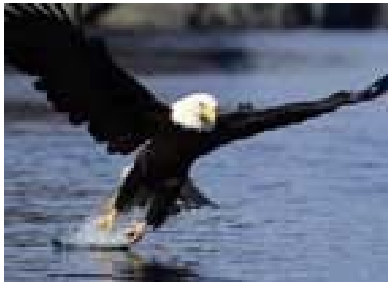
Regulatory Overview

The U.S. DOT Hazardous Liquid Pipeline Integrity Management rule (CFR 195.452) requires operators to:

- Identify where pipeline releases could potentially affect **High Consequence Areas (HCAs)**.
- Meet prescriptive requirements for periodic **Inspection and Repair**.
- Conduct Risk Analyses to evaluate the need for additional **Preventive & Mitigative Measures**, to prevent and/or mitigate the impact of a release to HCAs.
- An **Emergency Flow Restriction Device (EFRD)** is a special class of Preventive & Mitigative Measure identified in the regulation.

High Consequence Areas (HCAs)

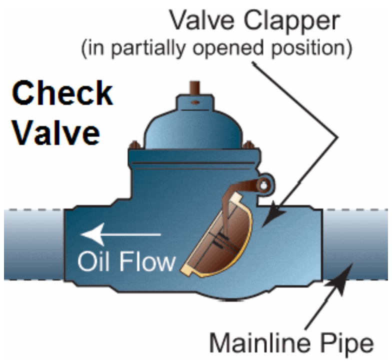


For Hazardous Liquid Pipelines...

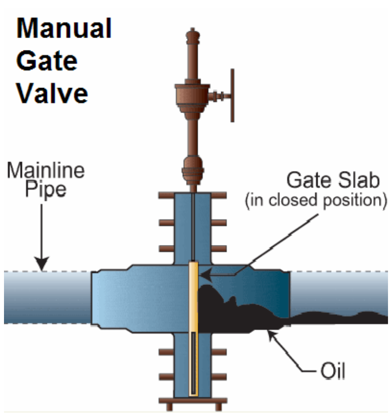
- High Population Areas.
- Other Populated Areas.
- Unusually Sensitive Areas:
  - Ecological
  - Drinking Water
- Commercially Navigable Waterways.

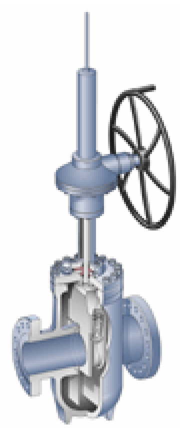
What is an EFRD?

An **Emergency Flow Restriction Device (EFRD)** is defined as either a **Check Valve** or **Remote Control Valve**.



A **Check Valve** automatically prevents backflow when the pipeline shuts down.





A <u>Manual Gate Valve</u> can be converted into a **Remote Control Valve** by adding a <u>Motor Operator</u> and <u>SCADA Controls</u> to enable timely remote closure (e.g. from a pipeline control center).

EFRD Adequacy Evaluation

Chevron Pipe Line Company (CPL) uses various GIS toolsets to evaluate the adequacy of Emergency Flow Restriction Devices (EFRDs).

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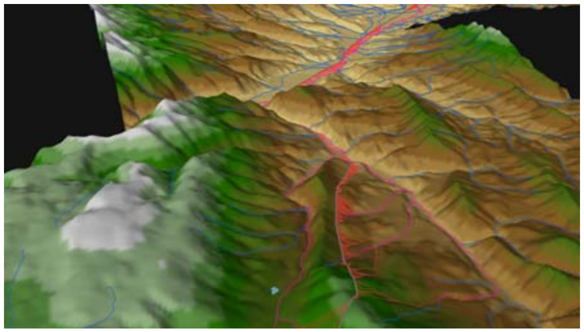
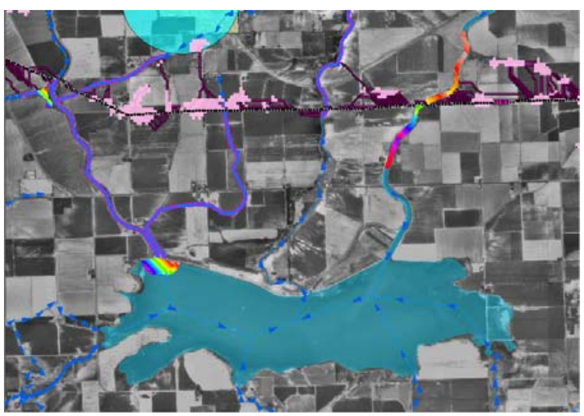
Again, EFRDs are valves and remote controls which mitigate the impact of a catastrophic rupture to HCAs.

Release Modeling

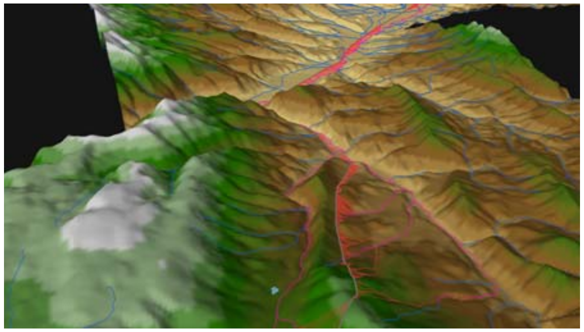


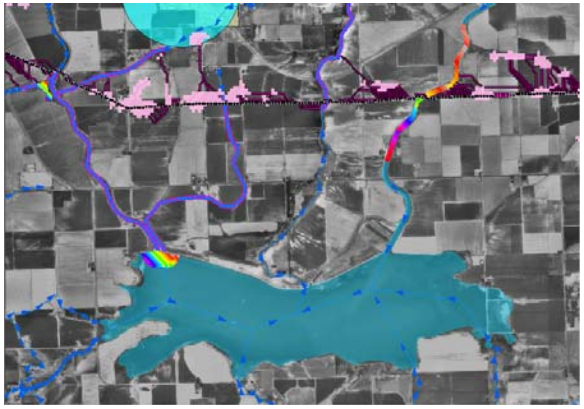


In order to measure the impact of a release to HCAs, the release volume and it's transport over land and water must be modeled relative to HCAs.

CPL uses a GIS based process for Pipeline Release, Overland Flow and Hydrographic Transport (PROFHT) modeling.

Release Modeling





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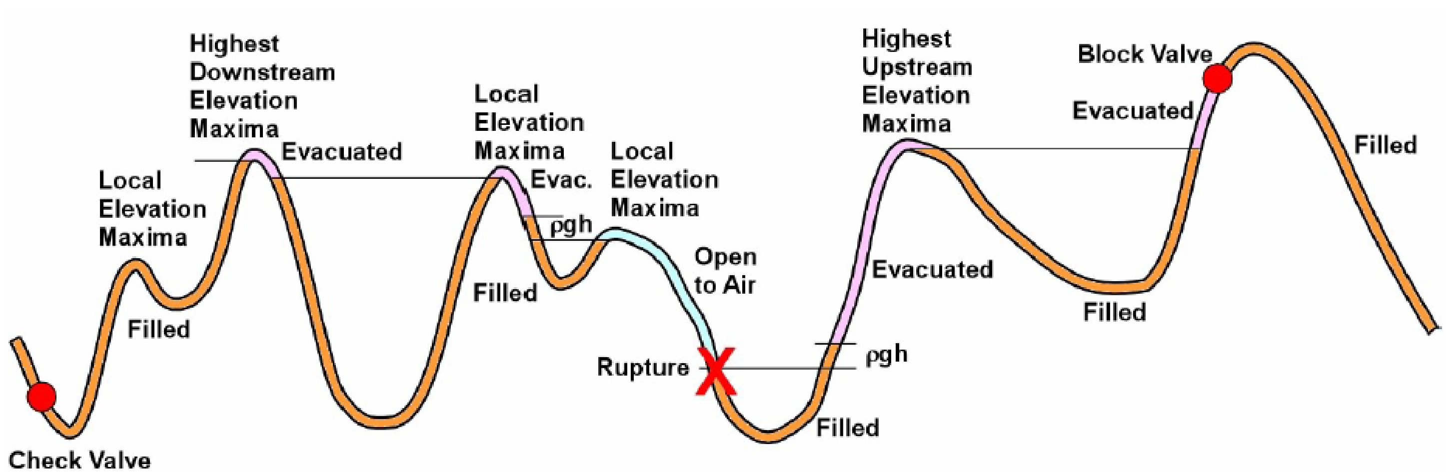
CPL uses a GIS based process for Pipeline Release, Overland Flow and Hydrographic Transport (PROFHT) modeling.

An understanding of pipeline drain down volume is a critical input to this release modeling process.

Modeling Drain Down Volume

- Release Locations
  - Model release every 100 ft.
- Failure Mechanism & Size
  - Third Party damage – full rupture.
  - Worst Case Discharge (WCD).
- Operating Conditions
  - Flow Rate.
  - Leak Detection & Response.
- Design Factors
  - Pipe diameter.
  - Valve type & spacing.



Overland Flow, Hydrographic Transport

Channelized Flow

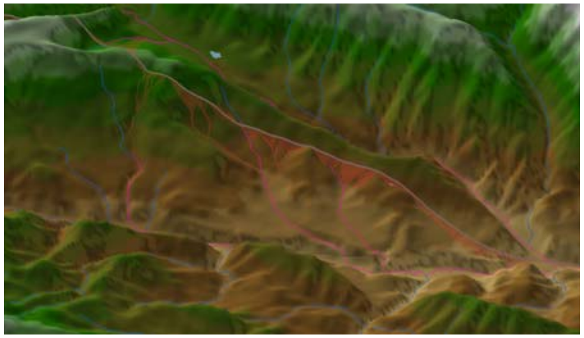
- Based on “Rain Drop” Tool.
  - Flow accumulation + flow direction
    ➔ least cost path.
  - Product fluxes include evaporation, infiltration, adhesion

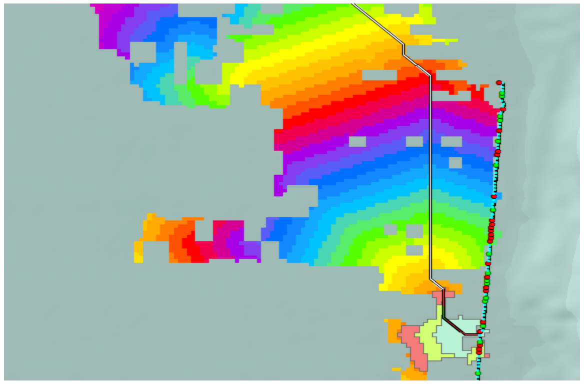
Lateral Spread

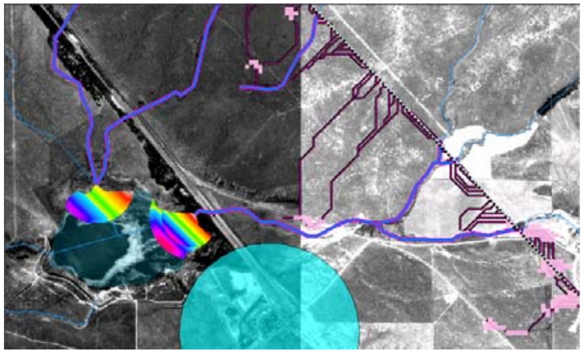
- Stepwise processing of “flat” areas.
  - Least cost flow surface to define time/distance intervals.
  - Tracks flow velocity, flow depth, product loss

Hydrographic Transport

- Relies on NHD dataset to determine stream network.
  - Product is transported downstream or as a radial surface plume in lakes
  - Transport distance is governed by stream velocity, product loss, and remaining response time

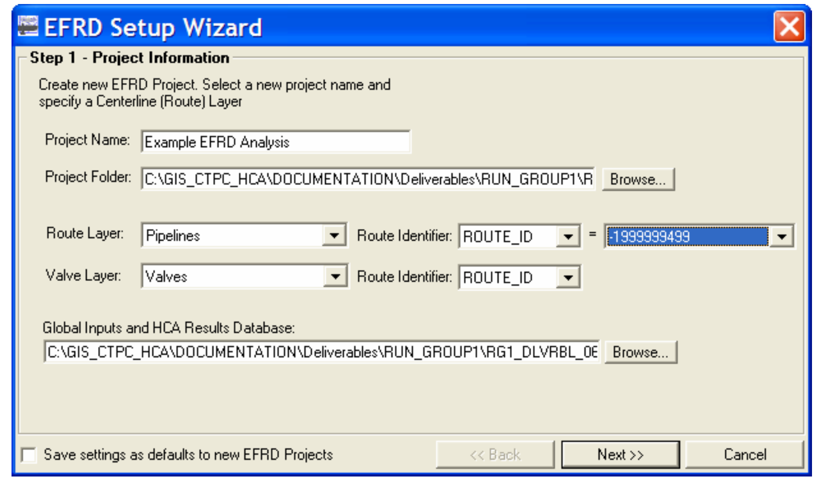


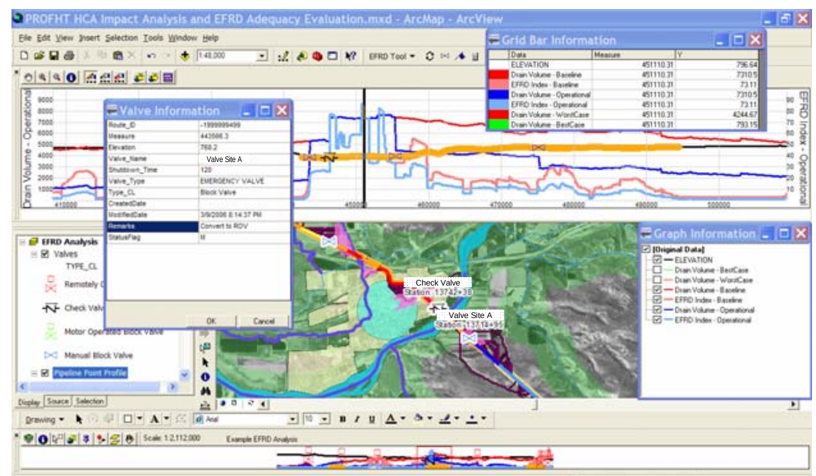




EFRD Advisor

After the release modeling is complete, an **EFRD Advisor** application uses GIS to provide an interactive viewing and modeling environment to facilitate the evaluation of potential EFRD improvements.

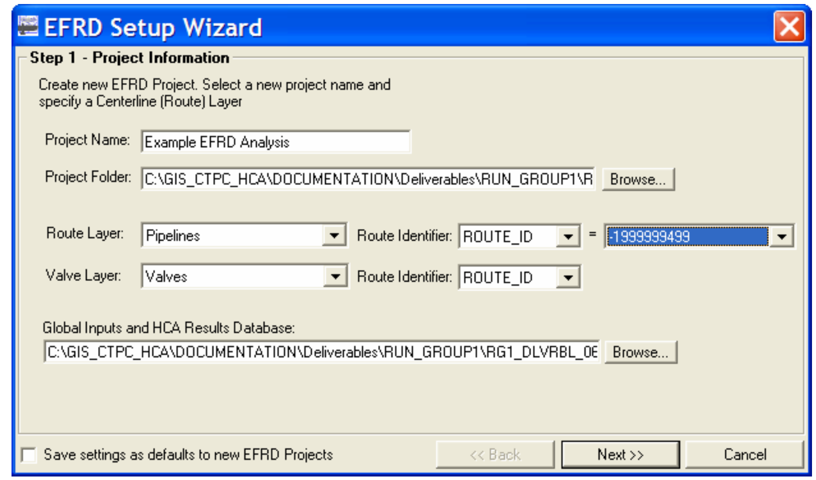


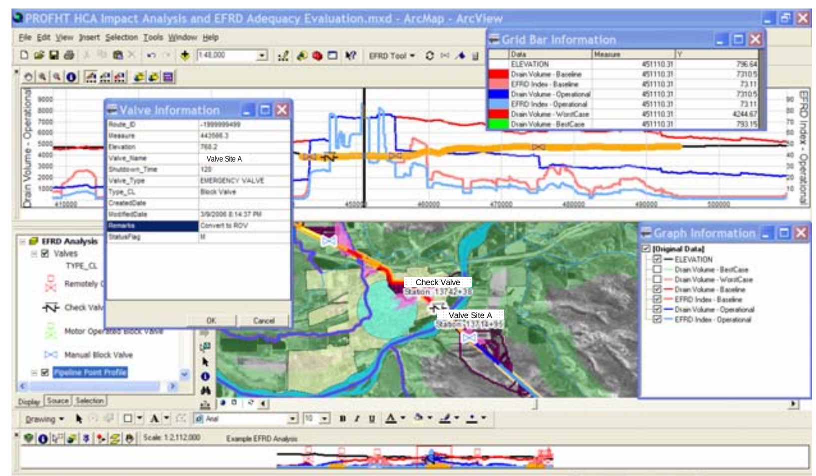


EFRD Advisor

After the release modeling is complete, an **EFRD Advisor** application uses GIS to provide an interactive viewing and modeling environment to facilitate the evaluation of potential EFRD improvements.

This application employs an **EFRD Index** as a measure of change in consequence relative to a **baseline analysis**.





Understanding Release Consequence

Before attempting to gauge the effect of placing a new valve, or reducing closure time on an existing valve, we must understand the **consequence** (negative impact) of a potential release along the pipeline.

Different releases will have different consequences, which will depend on the following factors:

- Release volume.
- Number and types of HCAs impacted:
  - Volume in;
  - Time of impact relative to Emergency Response time.
- Product type:
  - Some products have more severe impacts on certain HCA types than others.

Understanding A Consequence Index

A **Consequence Index** is a dimensionless quantity expressing ***relative*** consequence of releases within the context of a line segment.

A Consequence Index is:

- Internally consistent.
- Reproducible.
- Inherently arbitrary (e.g. parameters are adjustable).

A Consequence Index is <u>not</u>:

- Quantitative.
- Suitable for calculating absolute consequences.

A Consequence Index for a given scenario is calculated relative to a baseline analysis.

The EFRD (Consequence) Index

The **EFRD Index** is a **Consequence Index**

- The size of the release and associated HCA Impacts represent ***relative*** losses or costs.
  - Impact to Human Health & Safety.
  - Property Damage.
  - Environmental Damage.
  - Product Loss / Cleanup & Remediation Costs.

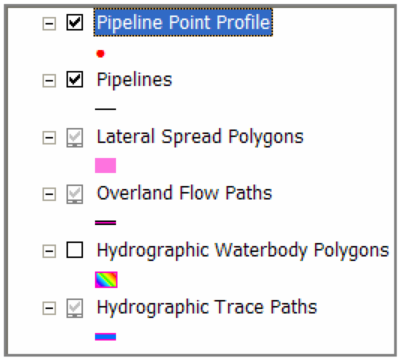
The EFRD (Consequence) Index Formula

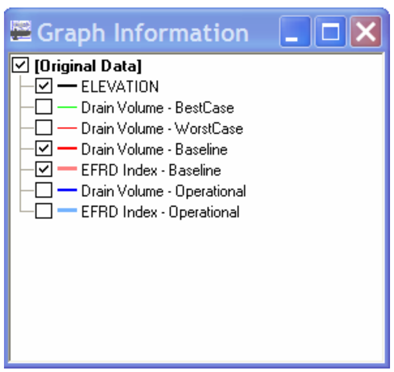
$$EFRD\_Index = \left(\frac{\left(1 + \sum_{HCAHits} \left(\frac{Rem\_Vol}{Drain\_Vol} * \frac{Rem\_Time}{Resp\_Time} * HCAwt \right)_{max} \right) * Drain\_Vol}{Avg\_Drain\_Vol} \right) * \left(\frac{EFRD\_Vol}{Drain\_Vol} \right) * Threat\_Index$$

Where:

- HCA Hit = Intersection of Rupture Point, Overland Flow Path or Polygon, Hydrographic Trace Path or Plume with an HCA.
- Rem_Vol = Remaining release volume introduced into an HCA.
- Drain_Vol = Total release volume at Rupture point for baseline scenario.
- Rem_Time = Time remaining to Resp_Time when an HCA is hit.
- Resp_Time = Emergency response time.
- HCAwt = Weight factors applied by HCA and Commodity type.
- Avg_Drain_Vol = Average release volume for all modeled rupture points on the line segment being analyzed. Can optionally be replaced by a user specified threshold drain volume to allow cross segment comparison.
- EFRD_Vol = Release volume calculated at the rupture point for the EFRD scenario under consideration.
- Threat_Index = optional estimate of relative threats along the pipeline.

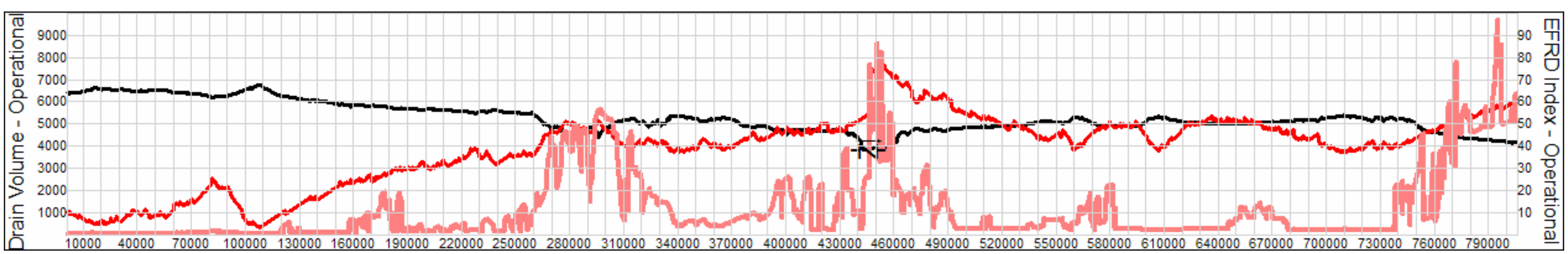
EFRD Adequacy Evaluation Process





Perform Pipeline Release, Overland Flow and Hydrographic Transport (PROFHT) Analysis.

- Baseline Drain Down Analysis.
  - Considers only existing Check Valves
- Baseline EFRD Consequence Index.
  - Calculated from HCA Intersections.
  - Uses weighting factors for:
    - HCA Type.
    - Commodity Type.



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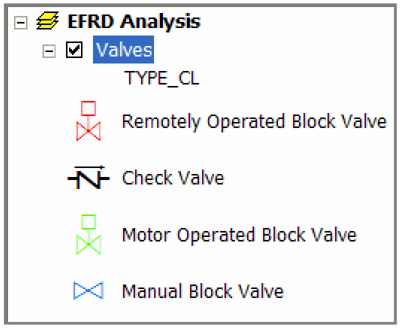
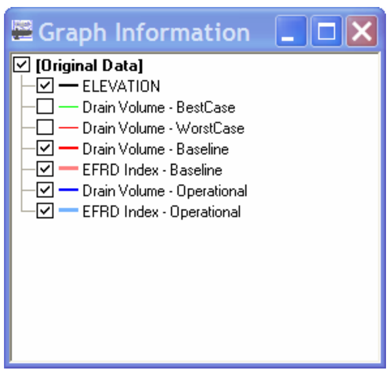


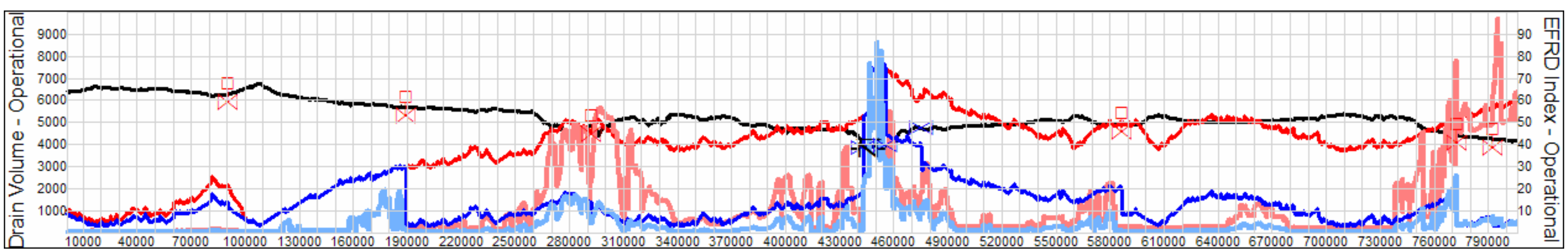


Perform Operational Drain Down Analysis

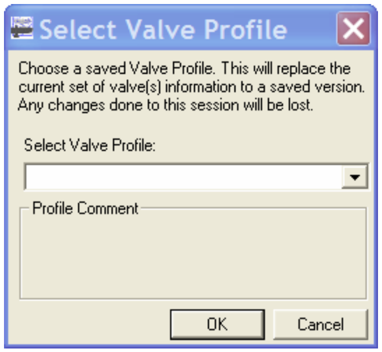
- Considers existing Remotely Operated Valves and Manual Block Valves
- Calculate Operational EFRD Index based on Reduced Drain Volumes.

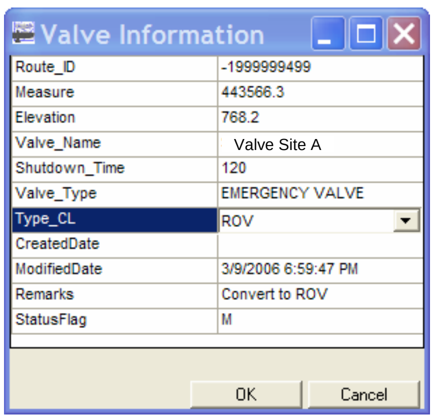
Evaluate Effectiveness of Existing EFRDs

- Compare EFRD Index between Baseline and Operational Scenario.
  - Expect to see Significant Reductions.



EFRD Adequacy Evaluation Process



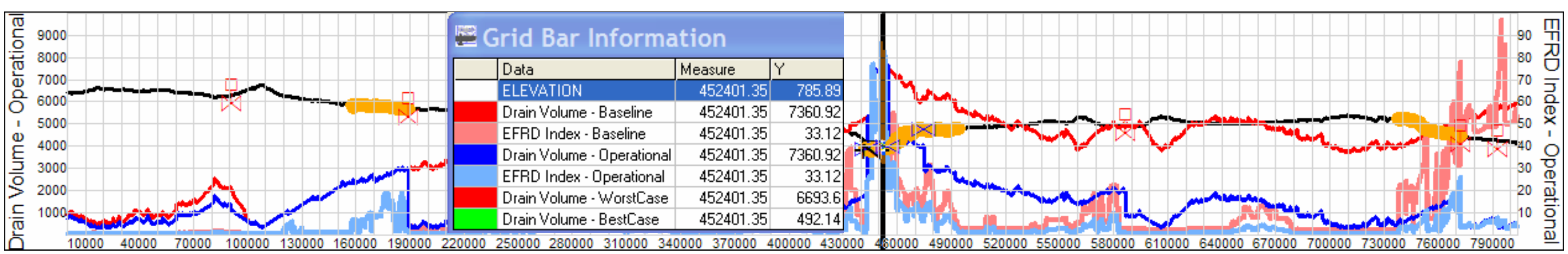


Identify and Prioritize Potential EFRD Evaluation Segments

- Where EFRD Index remains high.
- Where there is significant potential for Drain Volume reduction

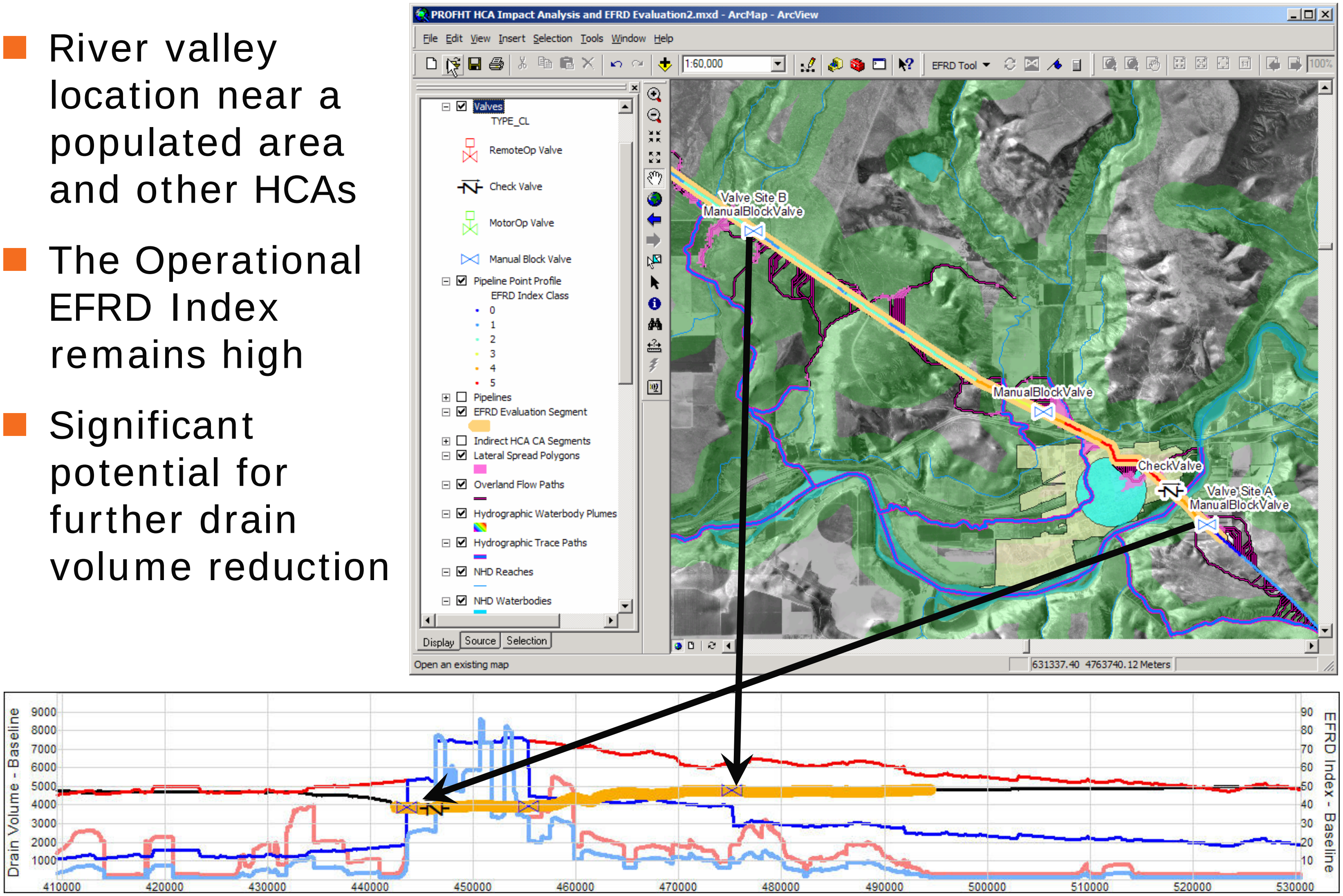
Identify Potential Valve Installations or Conversions

- Valve Conversions should be considered first.
- Consider site access and potential power sources



Example EFRD Adequacy Evaluation

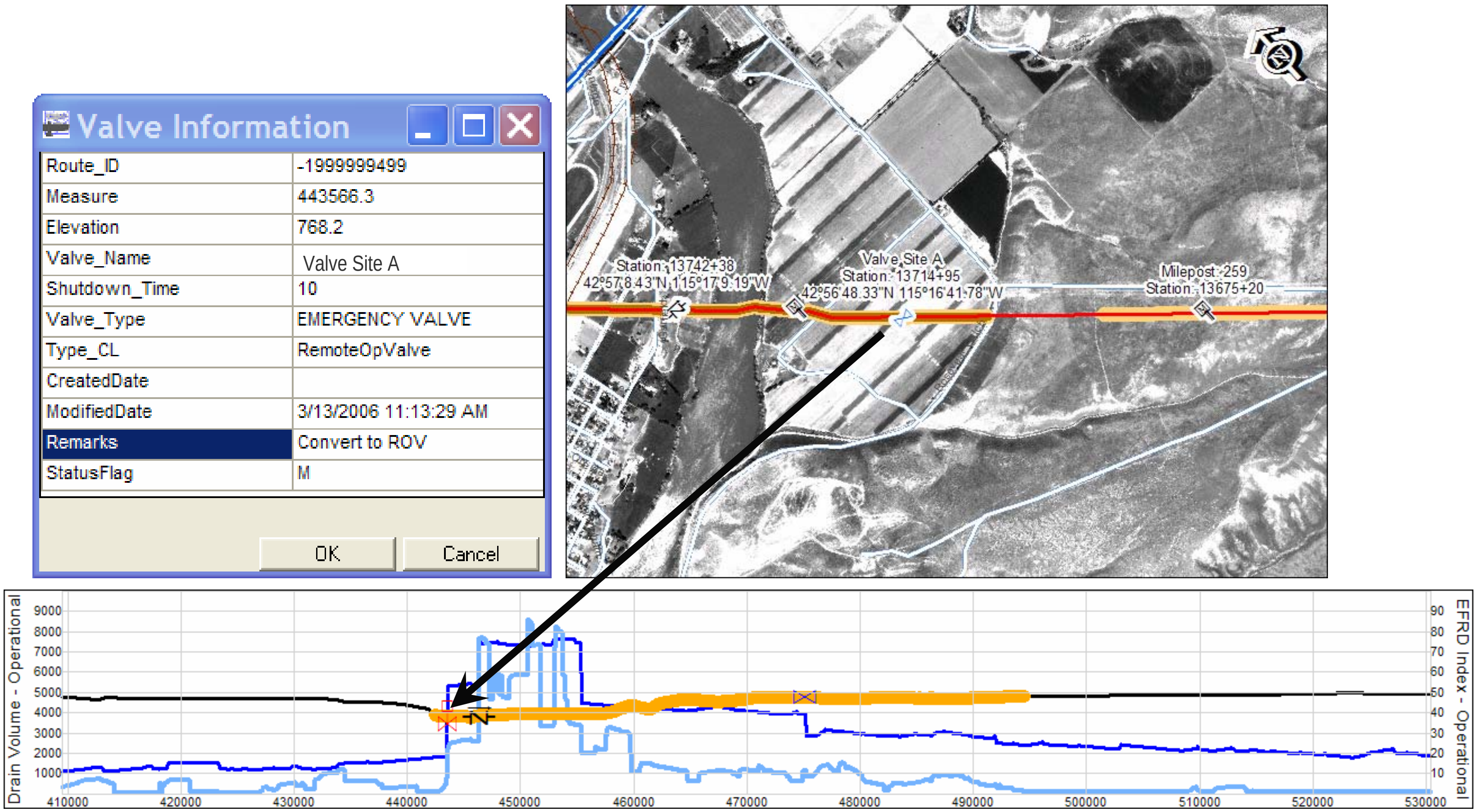
- River valley location near a populated area and other HCAs
- The Operational EFRD Index remains high
- Significant potential for further drain volume reduction



Example EFRD Adequacy Evaluation

Valve Site A: Existing manual valve, 2-hour closure.

- Convert to Remote Control Valve (EFRD), 10-minute closure.



Example EFRD Adequacy Evaluation

Valve Site B: Existing manual valve, 2-hour closure.

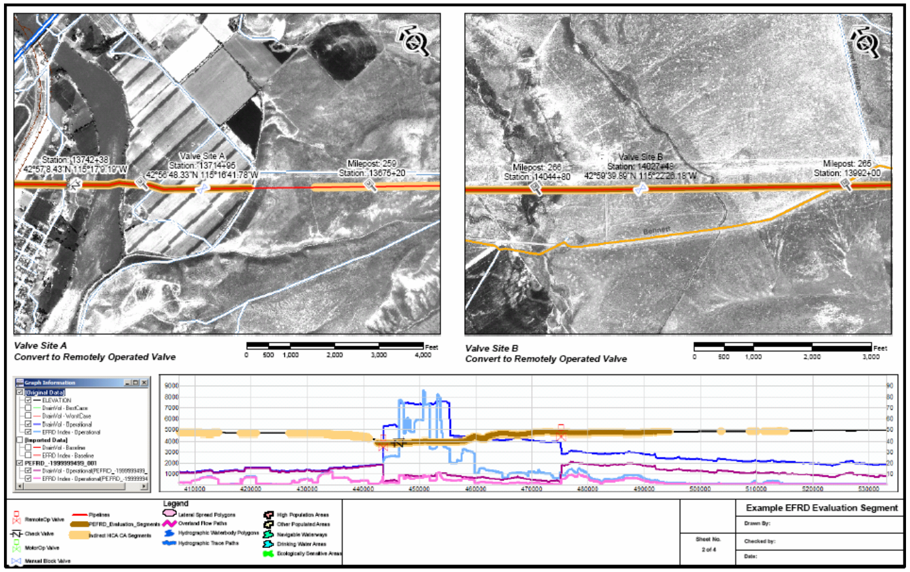
- Convert to Remote Control Valve (EFRD), 10-minute closure.

Example EFRD Adequacy Evaluation

- Tabular Reports

Line Name	Example Products Line	
Route_ID	999	
Route Name	Point A – Point B	
Segment Name	Example EFRD Evaluation Segment	
From_Stn	1370379.84	
From_Meas	442451.14	
To_Stn	1422058.7	
To_Meas	494509.80	
Length	52058.80	
	Max Baseline Drain_Vol	7624
	Avg Baseline Drain_Vol	6541
	Max Operational Drain_Vol	7624
	Avg Operational Drain_Vol	4283
	Max Proposed Drain_Vol	2130
	Avg Proposed Drain_Vol	1104
	Max Baseline EFRD_Index	86.3289
	Avg Baseline EFRD_Index	25.7063
	Max Operational EFRD_Index	86.3289
	Avg Operational EFRD_Index	19.2028
	Max Proposed EFRD_Index	11.4461
	Avg Proposed EFRD_Index	3.7977
	Avg Baseline EFRD_Class	3.0
	Avg Operational EFRD_Class	2.3
	Avg Proposed EFRD_Class	0.6

- Graphic Reports



‘EFRD’ Adequacy Evaluation

Questions ?