2D Floodplains and Floodways for Floodplain Managers

October 25, 2018

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

FEMA

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2D Floodplains and Floodways for Floodplain Managers

Purpose:

The use of combined 1-dimensional/2-dimensional (1D/2D) and/or full 2D models for FEMA floodplain studies has led to questions on how to use the models and their products for local floodplain management. A community's decision to use a 1D/2D or 2D model must take into consideration the pros and cons of 1D/2D and 2D analyses versus conventional 1D analyses. This guide is intended to help Floodplain Managers with that decision and answer questions regarding regulating floodplains based on results of 1D/2D or 2D models versus results from conventional 1D models.

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In this Guide:


1D vs. 2D Floodplains: Similarities vs. Differences

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FW How to Manage ***Without*** a 2D Floodway


LOMCs and Other Regulatory Processes

? Frequently Asked Questions

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1D vs. 2D Floodplains: Similarities vs. Differences

FW

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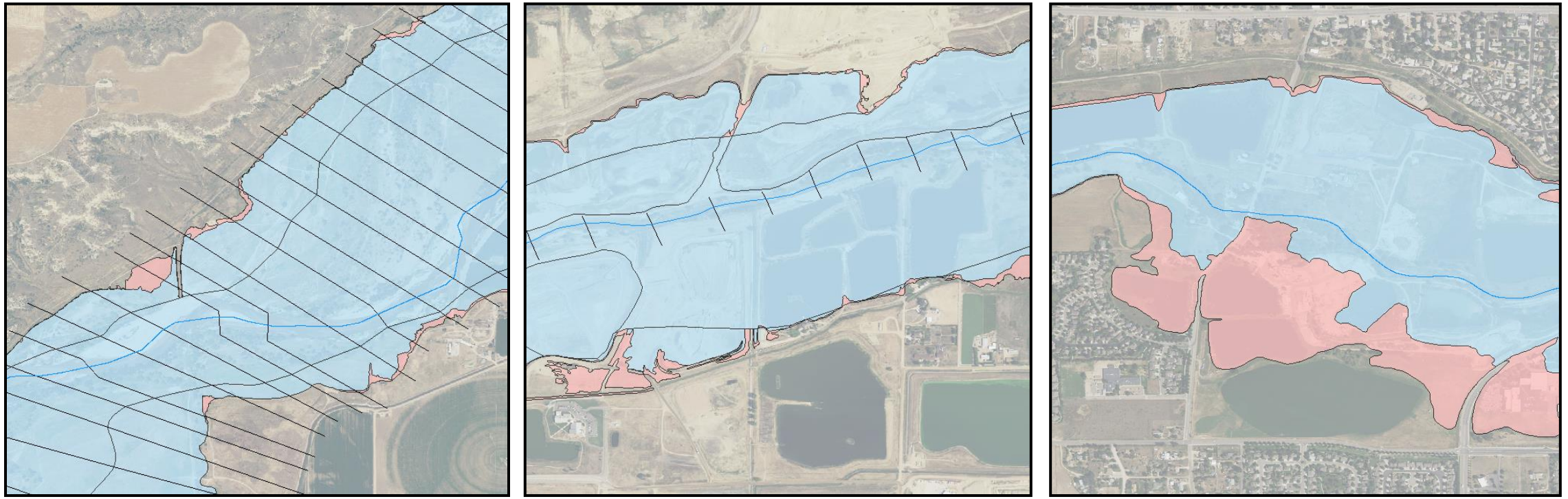
Similarities

1D, 1D/2D, and 2D models all produce 1% annual chance (100-year) and 0.2% annual chance (500-year) floodplain delineations. In other words, there is no difference in the way delineated floodplains are shown for 1D, 1D/2D, or 2D models.

1D **1D/2D** **2D**



1% Annual Chance 0.2% Annual Chance

Differences: Cross Sections

1D

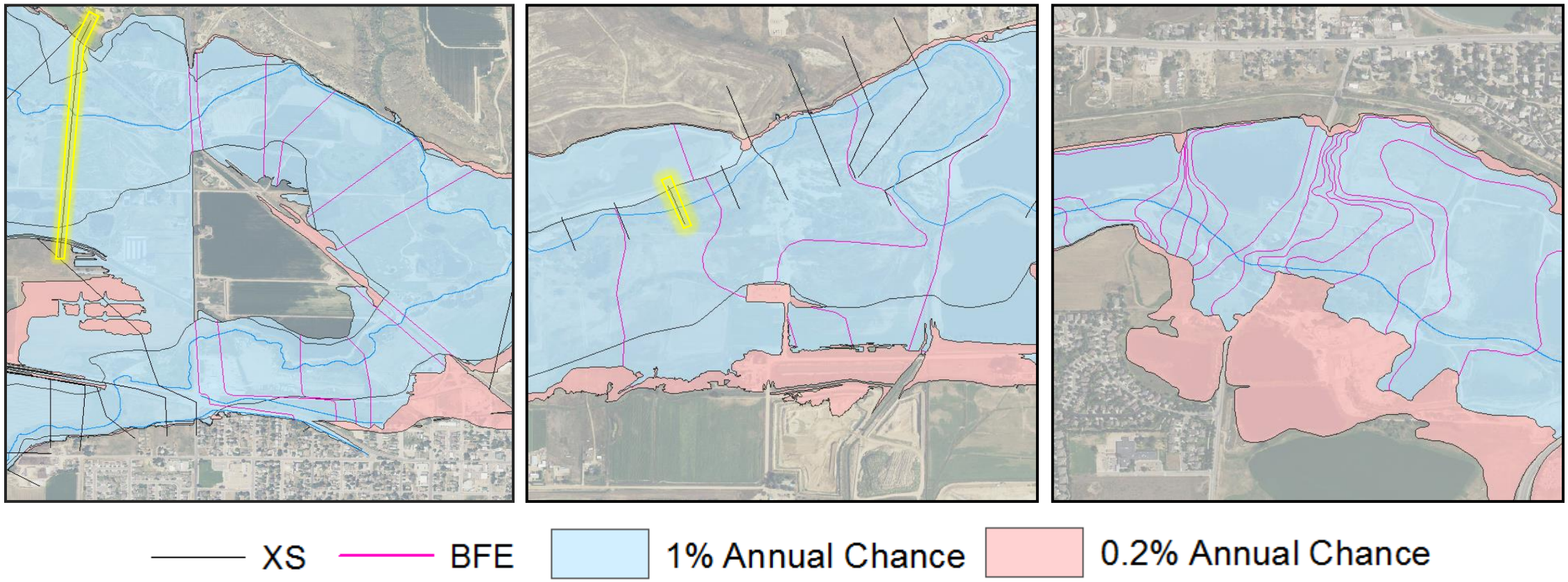
- Cross sections span the entire 0.2% annual chance floodplain and document the water-surface elevation (WSEL) at that location.

1D/2D

- Cross sections only cover a portion of the floodplain and the WSEL reported is only applicable for the extent of the cross section. For this reason, cross sections are not shown on the final Flood Insurance Rate Map (FIRM).

2D

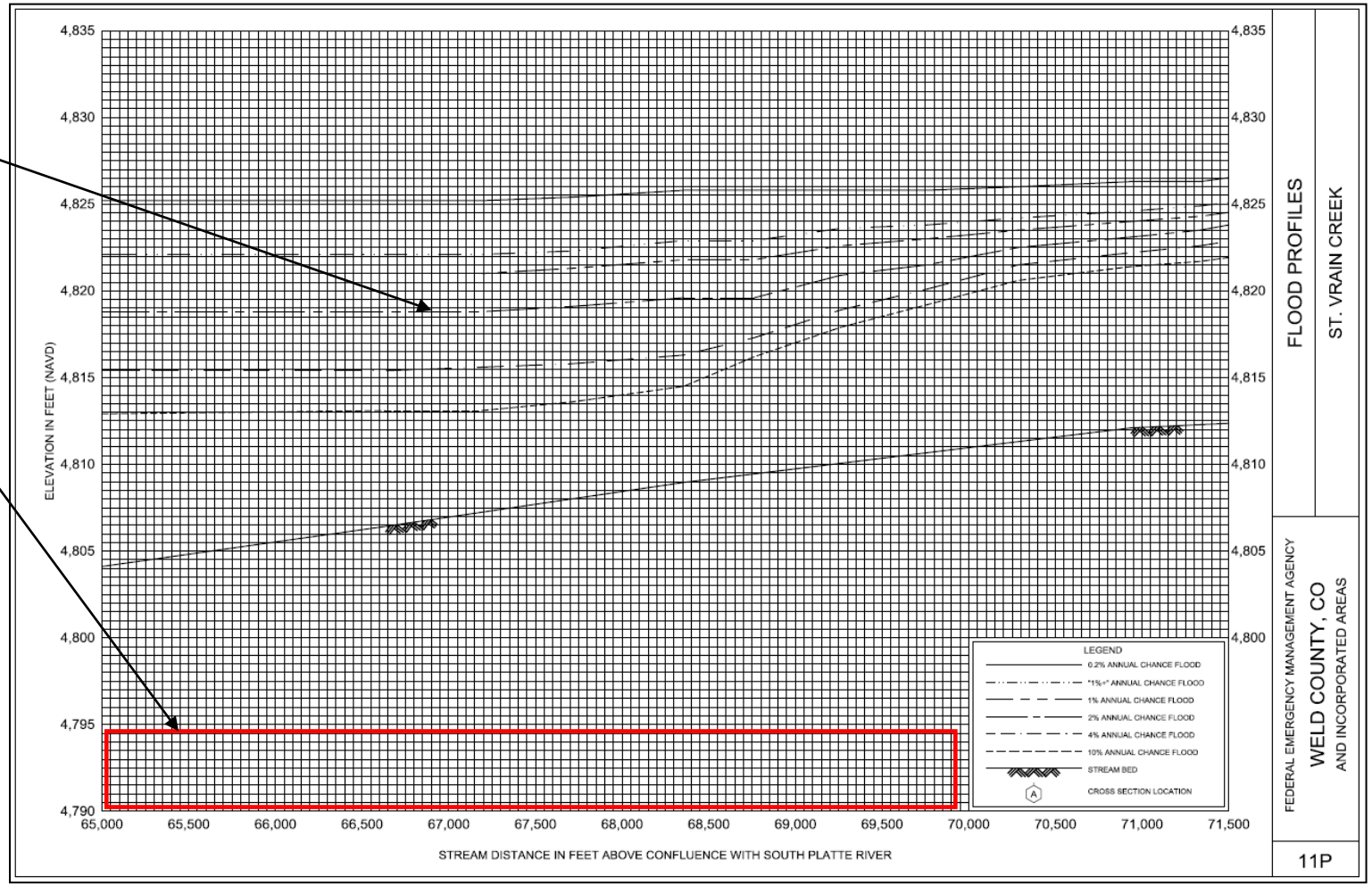
- There are no cross sections used in the model; therefore, no cross sections are shown on the FIRM.



Differences: Profiles

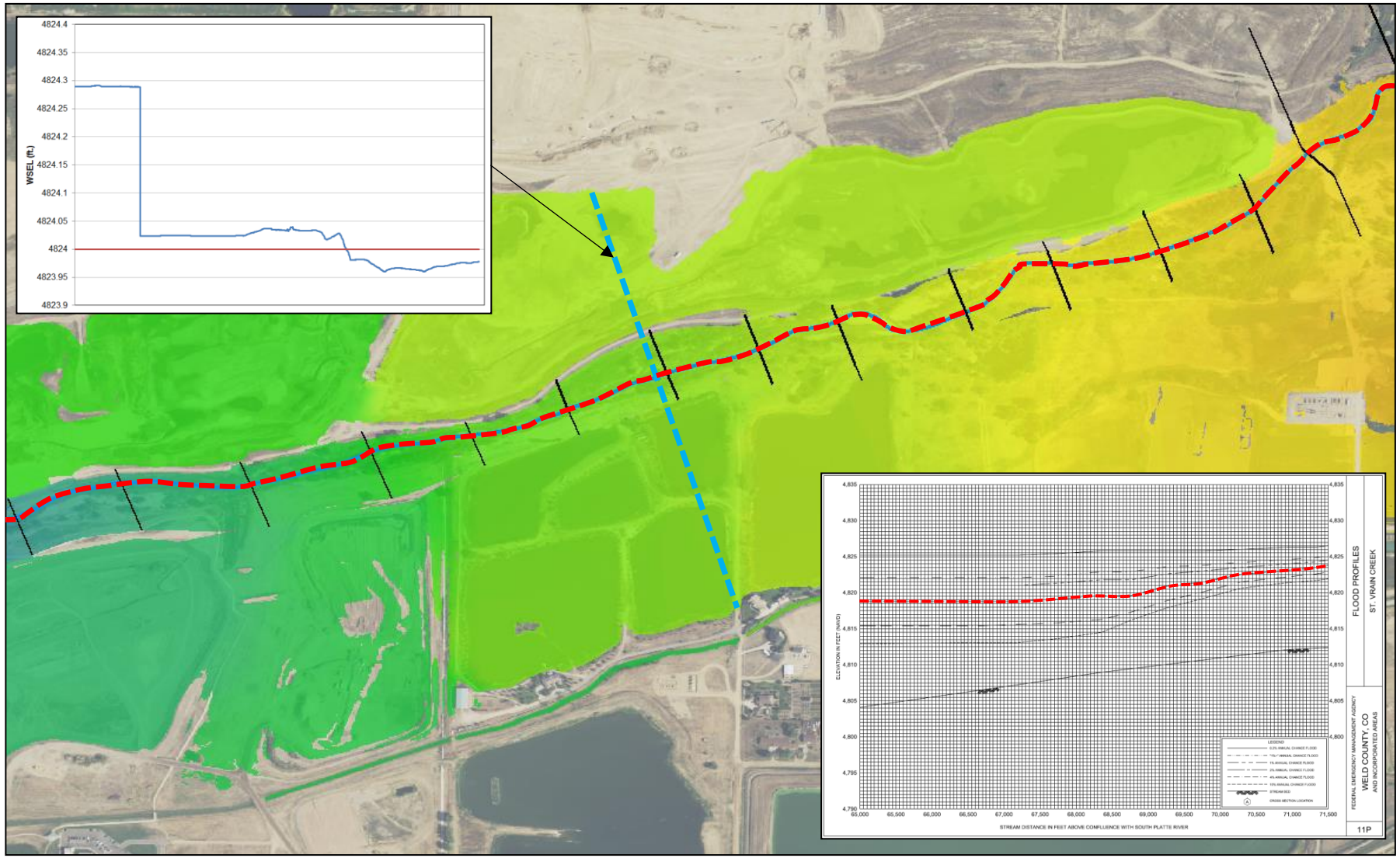
WSEL profile plots appear the same between 1D, 1D/2D, and 2D models; however, there are a few differences:

- 1D/2D and 2D profiles only show the WSEL along the profile baseline
- 1D/2D and 2D profiles do not have lettered cross sections shown on the profile

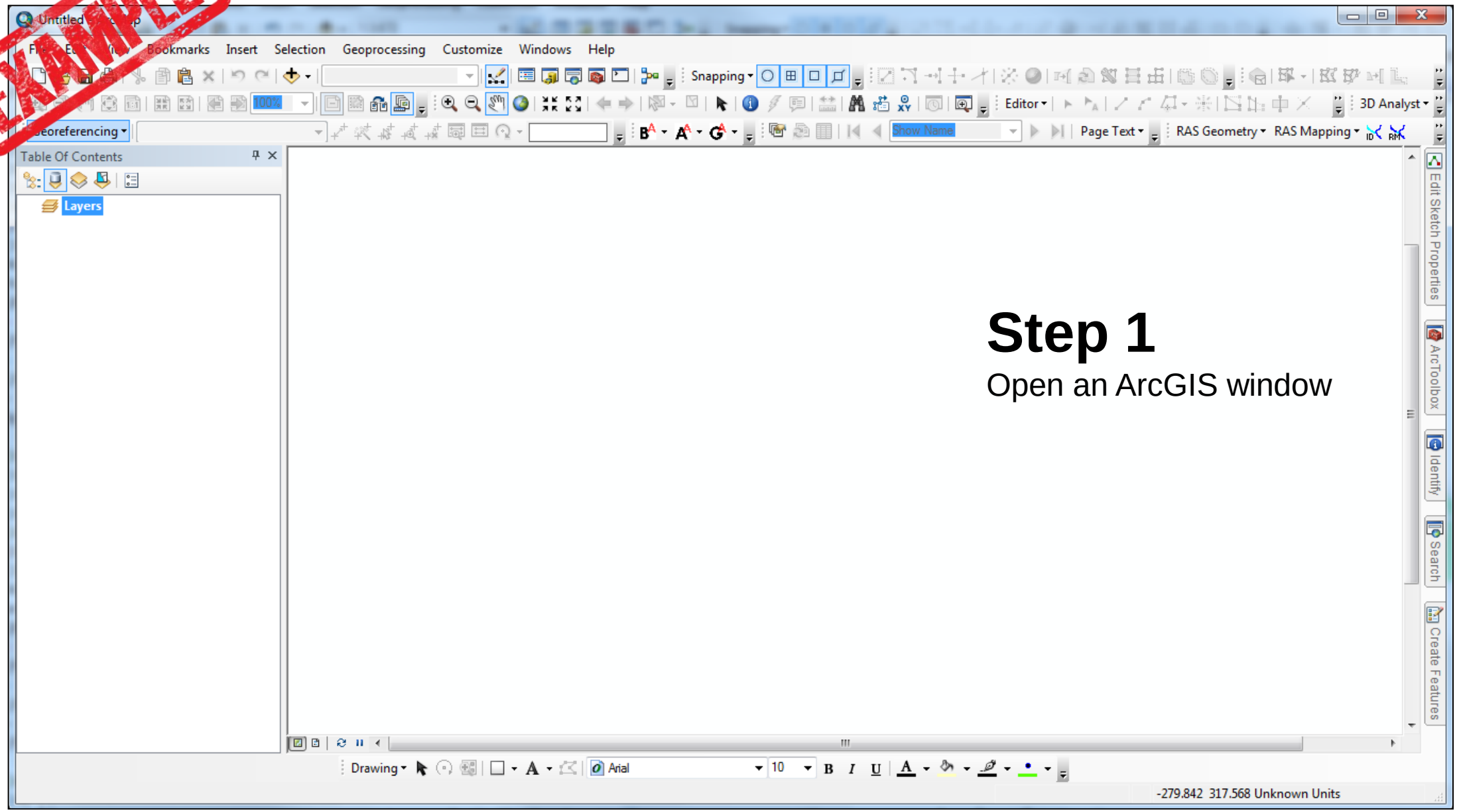


How are 2D profiles generated?

- 1D/2D and 2D profiles are generated from the WSEL along the profile baseline
- Because1D/2D and 2D models simulate flow in two directions, the profiles are not representative of the WSEL across the full floodplain.
- Contoured BFEs and WSEL grids are helpful in determining WSELs at specific locations.



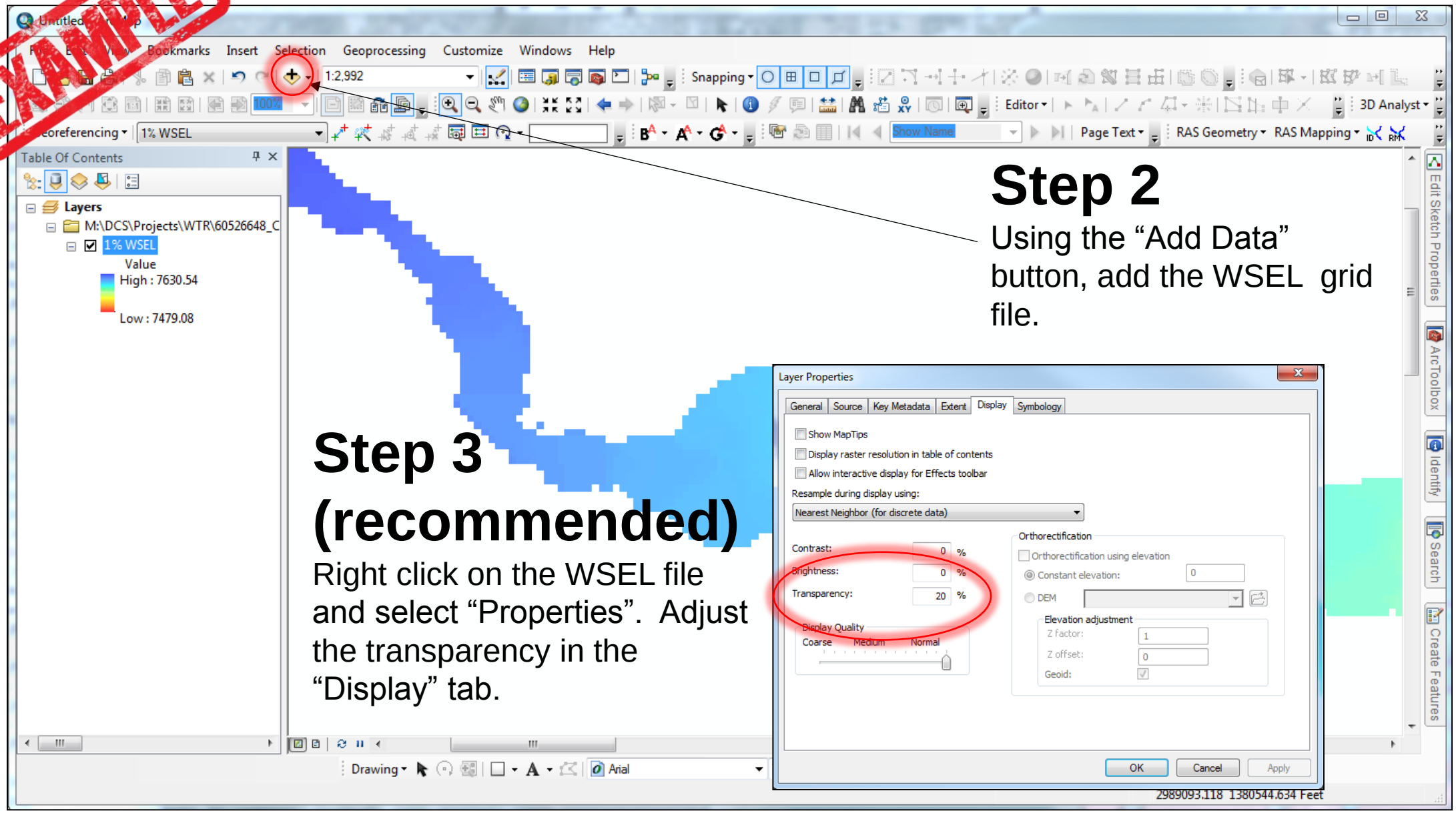
EXAMPLE



Step 1

Open an ArcGIS window

EXAMPLE



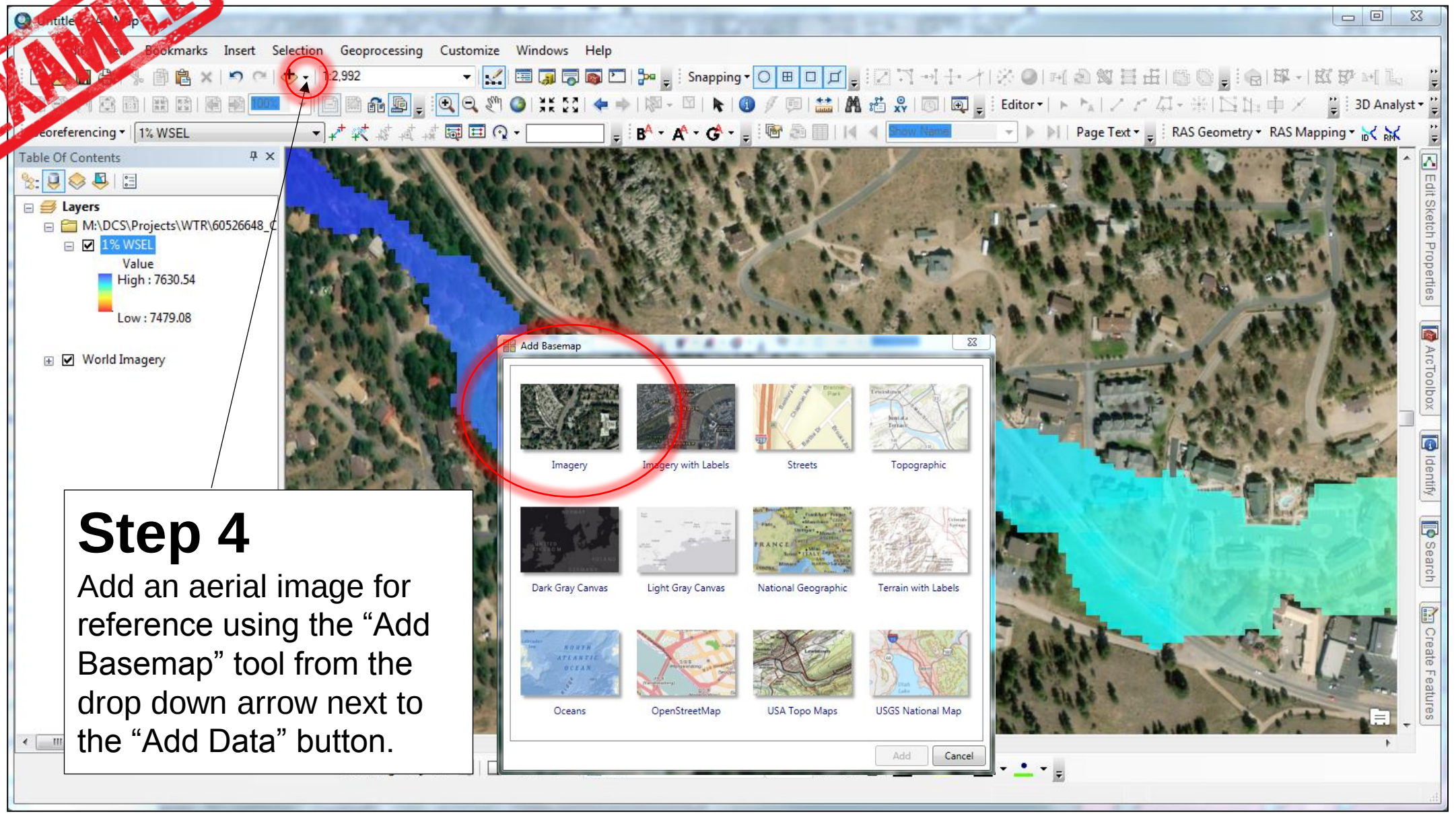
Step 2

Using the “Add Data” button, add the WSEL grid file.

Step 3 (recommended)

Right click on the WSEL file and select “Properties”. Adjust the transparency in the “Display” tab.

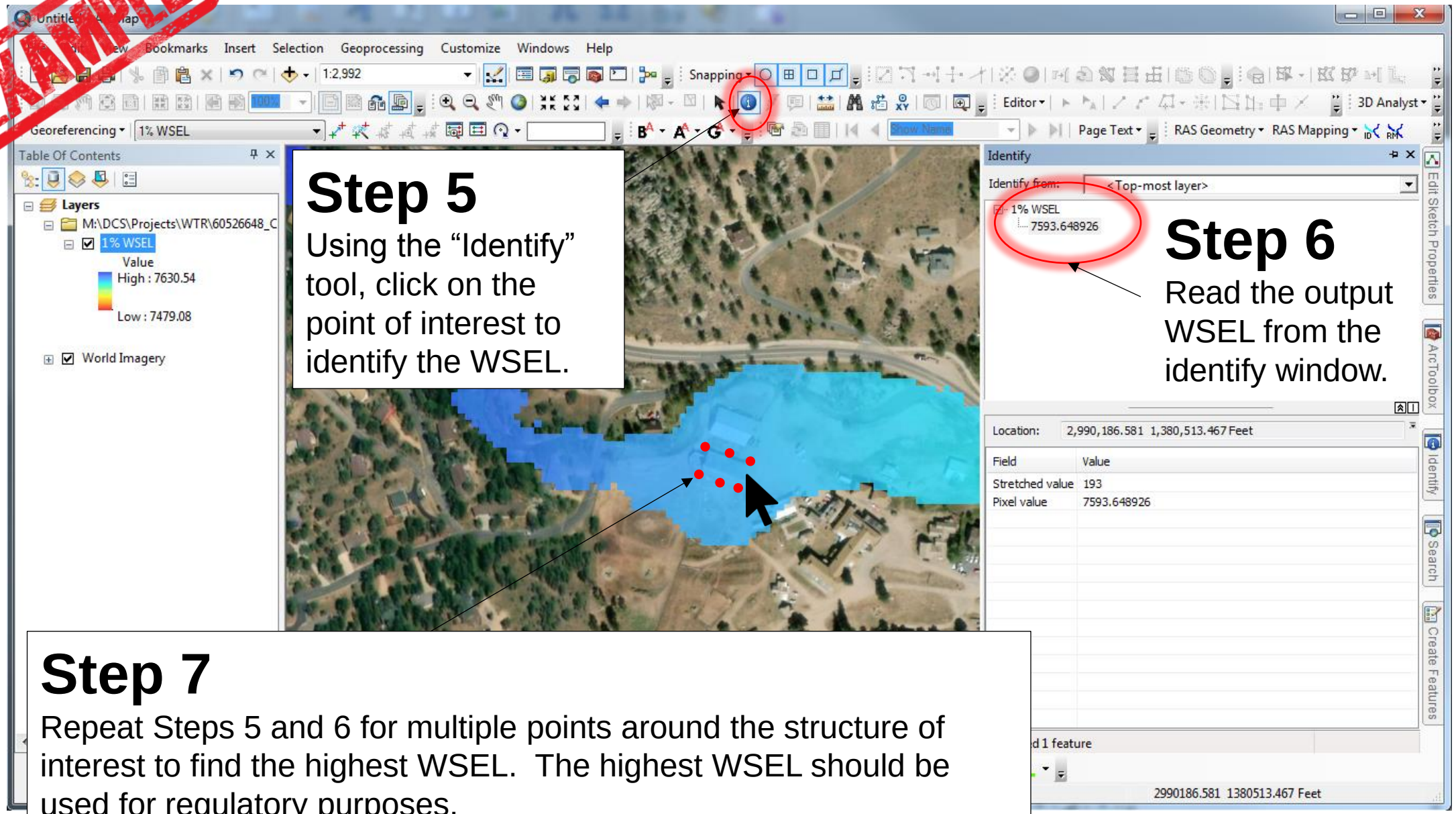
EXAMPLE



Step 4

Add an aerial image for reference using the “Add Basemap” tool from the drop down arrow next to the “Add Data” button.

EXAMPLE



Step 5

Using the "Identify" tool, click on the point of interest to identify the WSEL.

Step 6

Read the output WSEL from the identify window.

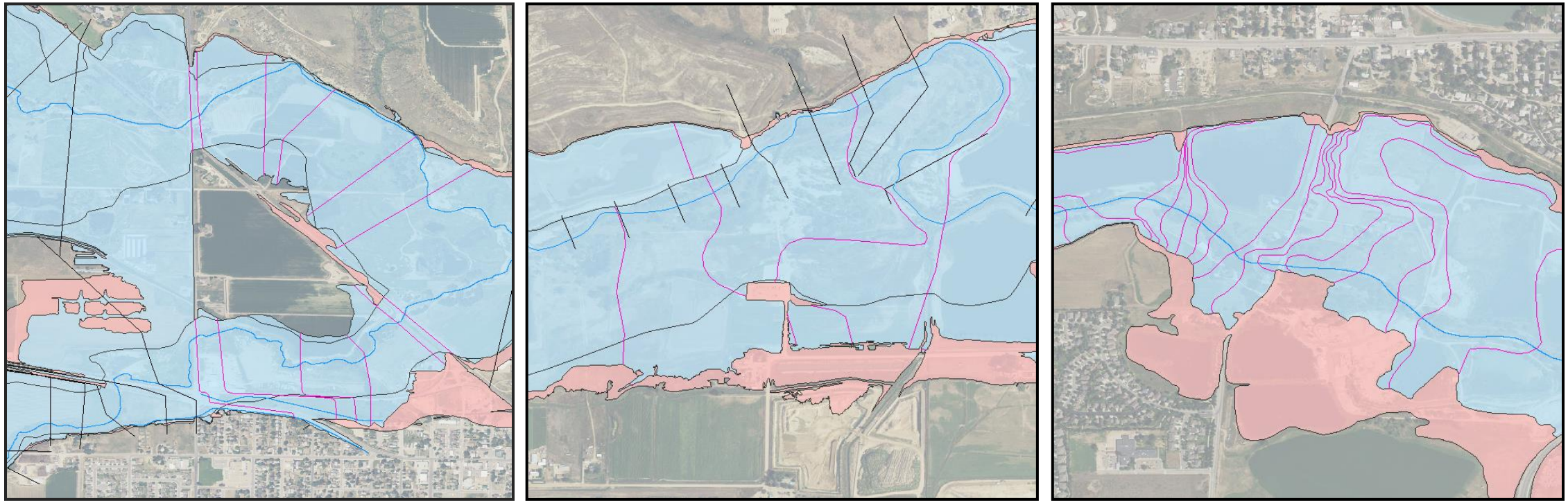
Step 7

Repeat Steps 5 and 6 for multiple points around the structure of interest to find the highest WSEL. The highest WSEL should be used for regulatory purposes.

Differences: BFE Lines

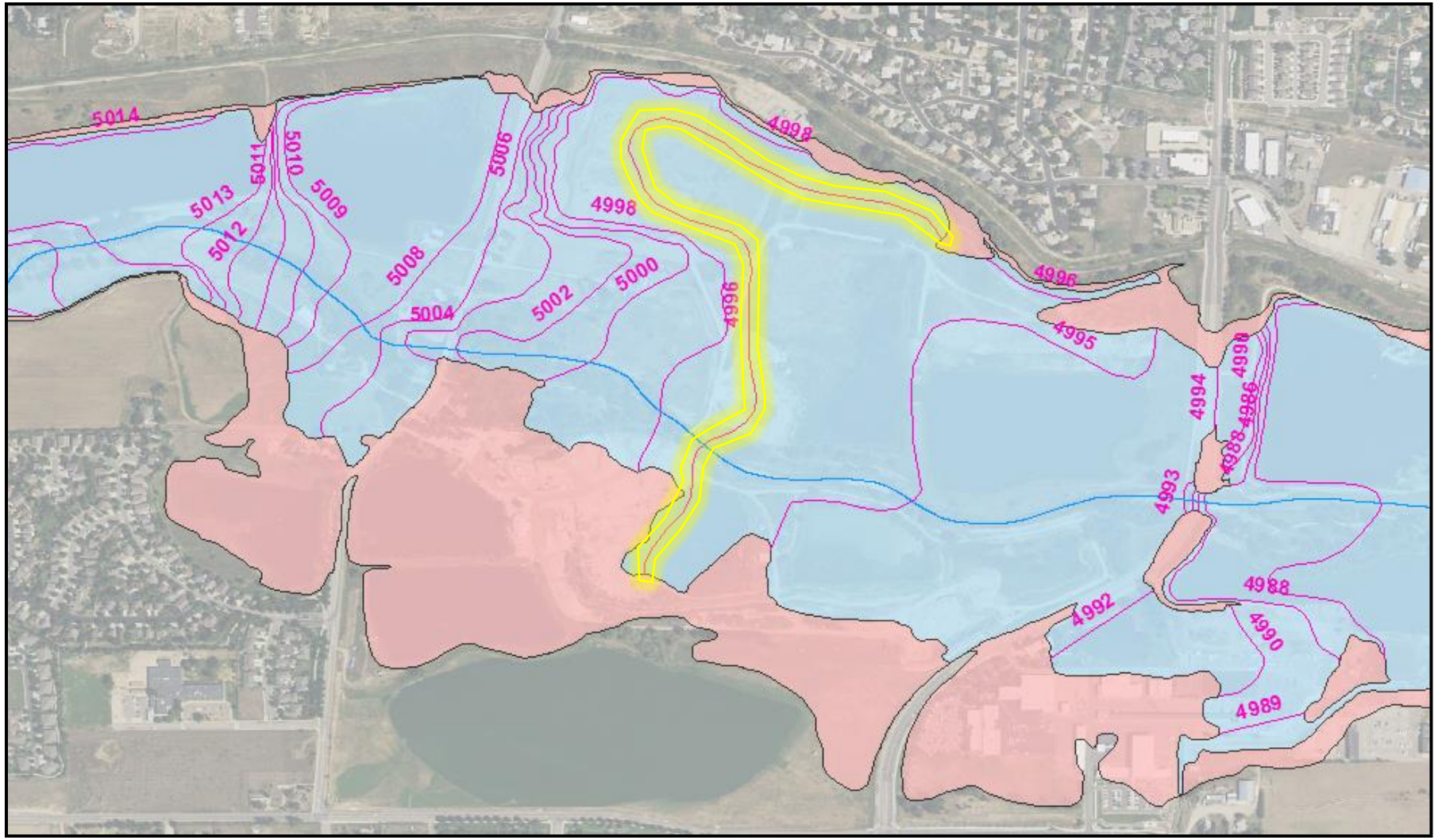
Based on current standards, Base Flood Elevation (BFE) lines for 1D models are used only at confluences and to show backwater elevation. Otherwise, 1D cross sections report WSELs. BFEs for 1D/2D and 2D models are contoured from the WSEL grid.

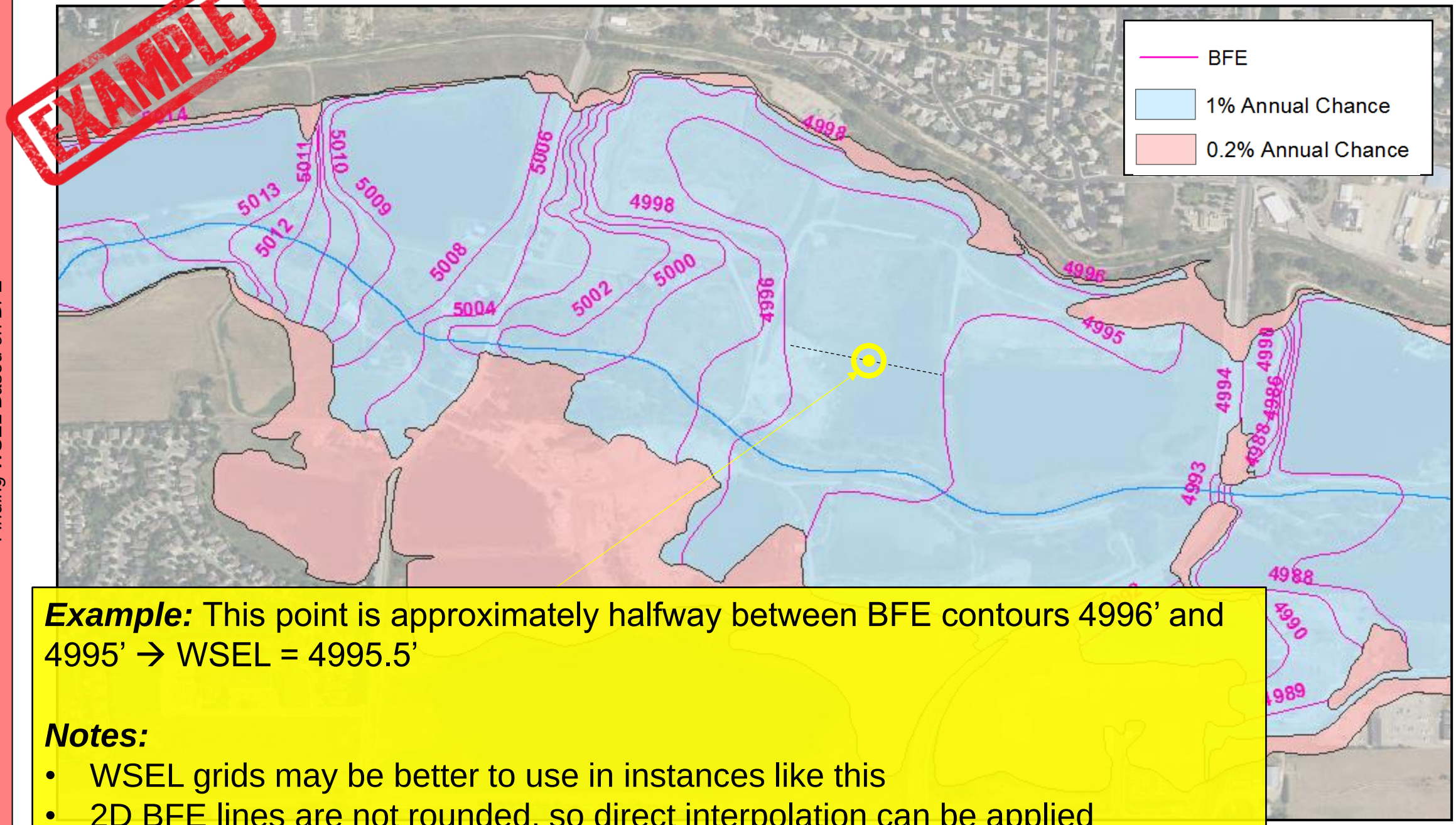
1D | **1D/2D** | **2D**



What is a contoured BFE?

- Contoured BFE lines, similar to contour lines for a topographic map, show lines of equal WSEL across the 1% annual chance floodplain.
- Contoured BFE lines are generated from WSEL grids created in the 1D/2D or 2D model. EXAMPLE





Example: This point is approximately halfway between BFE contours 4996' and 4995' → WSEL = 4995.5'

Notes:

- WSEL grids may be better to use in instances like this
- 2D BFE lines are not rounded, so direct interpolation can be applied

1D vs. 2D Floodplains: Similarities vs. Differences

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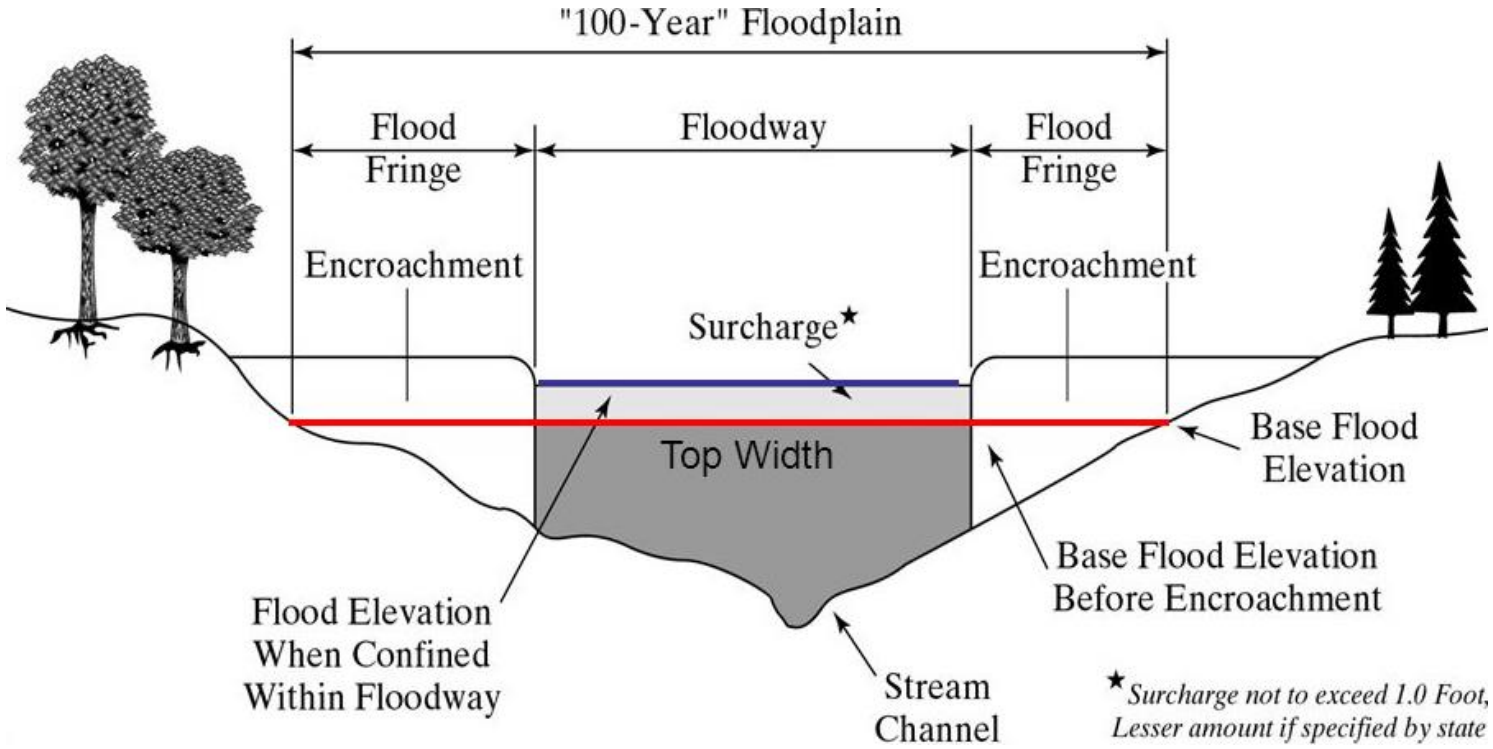
Purpose of the Floodway

FEMA's Definition

"A "Regulatory Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations."



Purpose of the Floodway (cont'd)

- The **floodway represents the "full build" or "ultimate" condition** that can occur without creating a surcharge greater than the designated height. The benefit of the floodway is that as development occurs, a new engineering study is not required to determine whether the development will cause a surcharge over the designated height. Instead, the development footprint can simply be compared against the effective floodway boundary.

- In other words, floodways make the job of a Floodplain Manager easier, because they serve as a tool for regulating development. However, with the introduction of 1D/2D and 2D models there are some additional things to consider:

  1) Floodway standards and guidance were established for 1D analyses. As a result, application to 1D/2D and 2D analyses is not straight forward and can be time intensive.

  2) Applying 1D floodway principles to 1D/2D and 2D models may result in a more restrictive floodway because of the resolution of the model results.

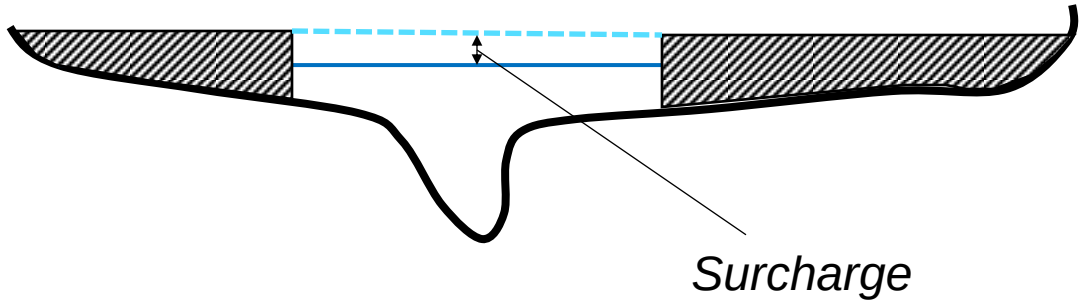
Basics of 1D/2D and 2D Floodways

- The major difference between a 1D and either 1D/2D or 2D floodway is that the surcharge in a 1D model is averaged across the entire cross section, whereas surcharges in 1D/2D and 2D floodways are evaluated at each computational cell. As a result, 1D floodways effectively "dampen" out extreme localized surcharges, whereas 1D/2D and 2D floodways do not.

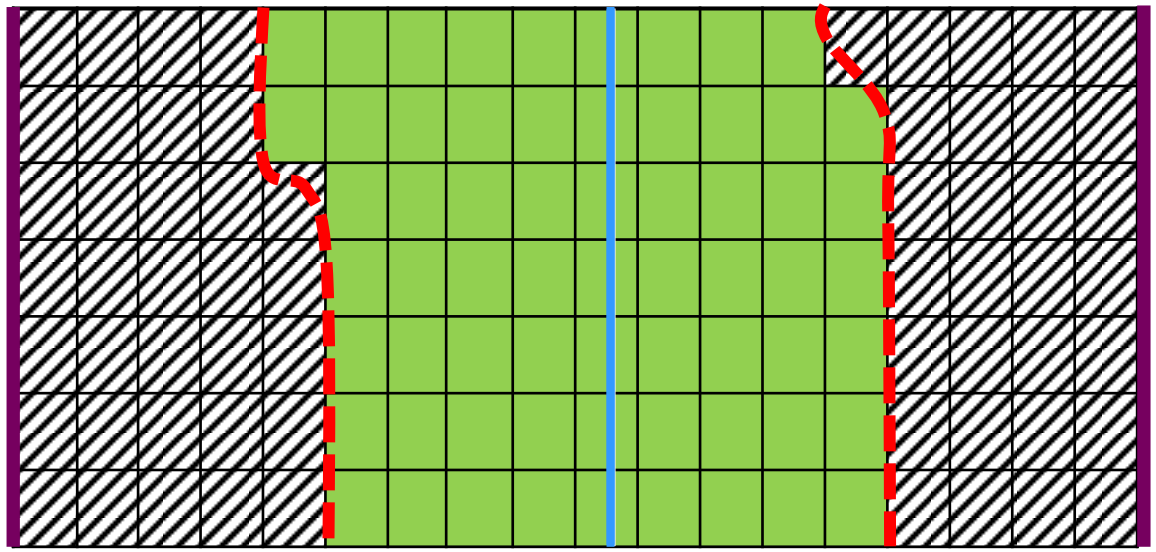
So what does that mean?

- **1D/2D and 2D floodways tend to be much wider because each cell must fall within the surcharge range**. In a 1D/2D or 2D model there are 10,000s of locations that must satisfy the surcharge standard versus in a 1D model where there are 10s or 100s. EXAMPLE

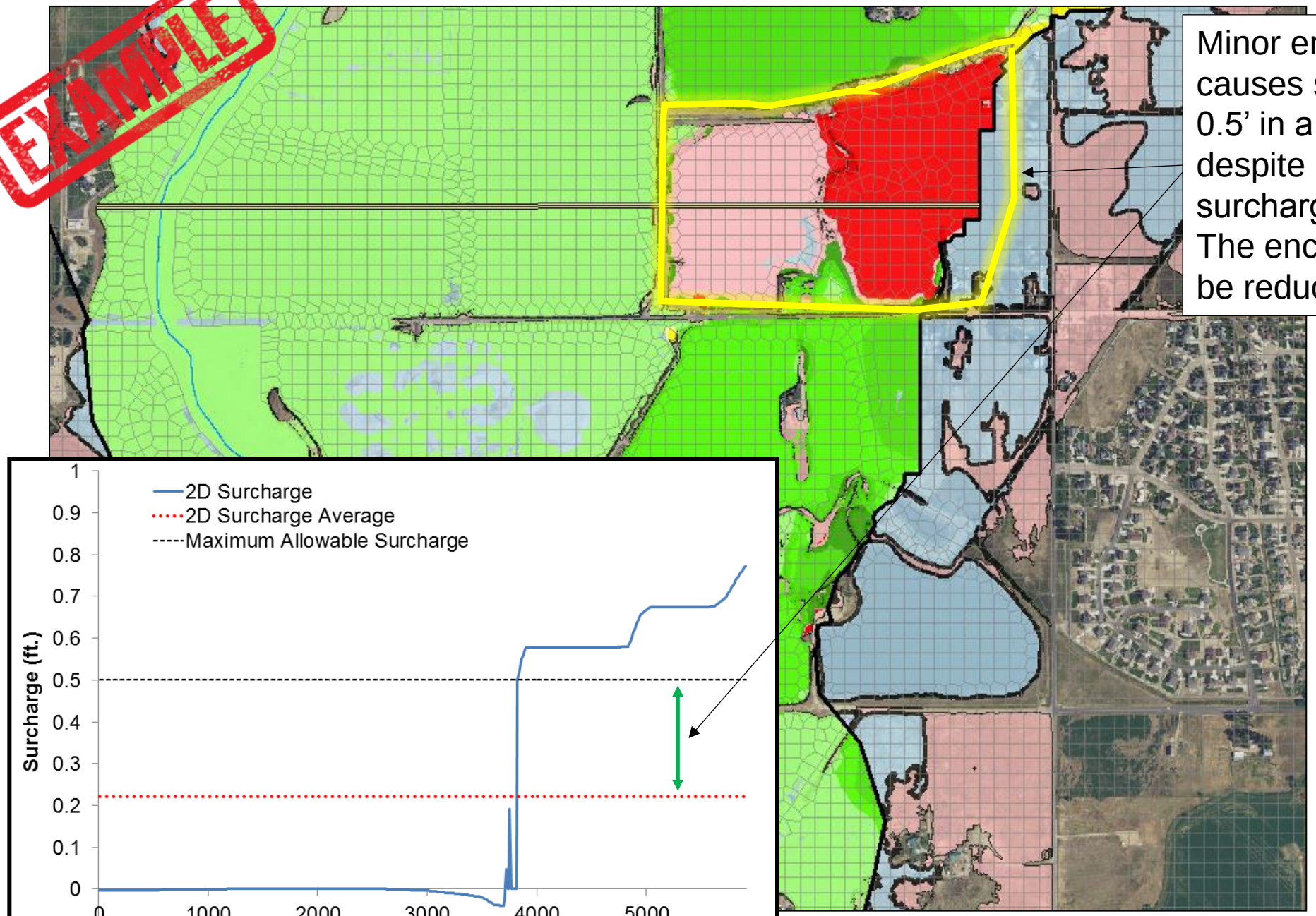
1D Floodway



2D Floodway



EXAMPLE


Minor encroachment causes surcharges above 0.5’ in a localized area, despite having an average surcharge well below 0.5’. The encroachment must be reduced.
Encroachment
2D Cell
Surcharge (ft.)
< -0.1
-0.1 - 0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
> 0.6

2D Surcharge
2D Surcharge Average
Maximum Allowable Surcharge
Surcharge (ft.)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
1000
2000
3000
4000
5000
Distance (ft.)

Managing a 1D/2D or 2D Floodway

- The tools available for managing a 1D/2D or 2D floodway are the same as those available for typical 1D models, including:

Floodway Data Table

EXAMPLE

Table 24: Floodway Data

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/ SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
[2]	33,346	1,539	*	7.4	4,955.0	4,955.0	4,955.2	0.2
[2]	35,685	2,770	*	6.9	4,964.0	4,964.0	4,964.0	0.0
[2]	37,219	3,197	*	10.3	4,966.0	4,966.0	4,966.1	0.1
[2]	38,893	1,649	*	7.1	4,971.0	4,971.0	4,971.0	0.0
[2]	39,818	1,392	*	6.7	4,974.0	4,974.0	4,974.0	0.0
[2]	41,855	2,161	*	7.3	4,980.0	4,980.0	4,980.0	0.0
[2]	42,716	3,100	*	5.7	4,983.0	4,983.0	4,983.1	0.1
[2]	44,385	2,917	*	7.0	4,989.0	4,989.0	4,989.1	0.1
[2]	45,454	2,143	*	4.6	4,994.0	4,994.0	4,994.0	0.0
Station 45,563-96,222**								

[1]Feet above confluence with St. Vrain Creek
[2]Values computed using a 2D model. Locations are represented by BFEs on the FIRMs. Additional information is available to help determine floodway information including depth and velocity grids. Contact the Boulder County Floodplain Administrator for more information.
*Data not available
**Administrative floodway. Model results not available. Contact the Boulder County Floodplain Administrator for more information.

TABLE 24 | FEDERAL EMERGENCY MANAGEMENT AGENCY | BOULDER COUNTY, CO | AND INCORPORATED AREAS | FLOODWAY DATA | FLOODING SOURCE: BOULDER CREEK

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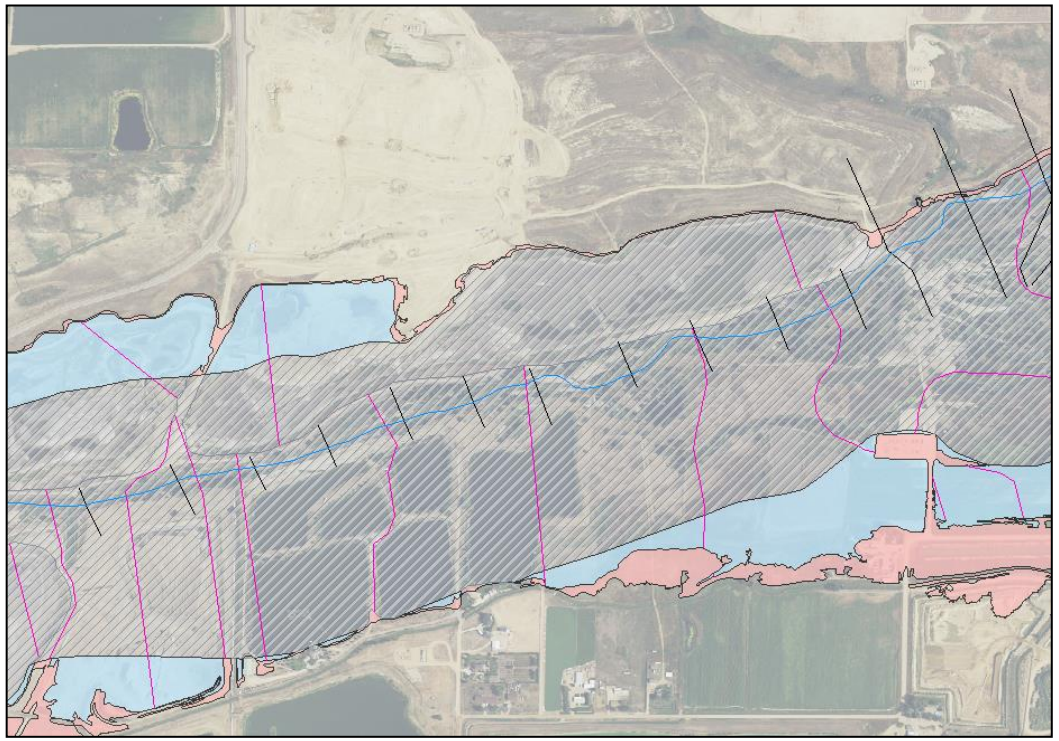
Mapped Floodway



- But, the information provided within the tools is slightly different and there is additional information aside from those tools that can help with floodway management.

EXAMPLE

LOCATION CROSS SECTION	LOCATION DISTANCE[1]	FLOODWAY WIDTH (FEET)	FLOODWAY SECTION AREA (SQ. FEET)	FLOODWAY MEAN VELOCITY (FEET/ SEC)	1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88) REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
CJ	150,199	115	497	10.1	6,074.7	6,074.7	6,074.8	0.1
CJ	151,524	49	339	14.8	6,105.8	6,105.8	6,106.0	0.2
CK	152,663	50	347	14.5	6,133.9	6,133.9	6,133.9	0.0
CL	153,337	36	328	15.3	6,162.1	6,162.1	6,162.5	0.4
CM	154,170	80	404	12.5	6,187.3	6,187.3	6,187.3	0.0
CN	155,171	40	318	15.8	6,225.0	6,225.0	6,225.0	0.0
CO	156,199	43	327	15.4	6,252.3	6,252.3	6,252.4	0.1
CP	156,899	97	821	6.1	6,280.4	6,280.4	6,280.5	0.1
CQ	158,224	46	344	14.5	6,318.7	6,318.7	6,318.7	0.0
CR	159,109	58	365	13.7	6,342.8	6,342.8	6,342.8	0.0
CS	160,194	44	326	15.4	6,382.1	6,382.1	6,382.4	0.3
CT	160,599	64	662	7.6	6,401.1	6,401.1	6,401.4	0.3
CU	161,186	36	304	16.4	6,418.8	6,418.8	6,419.0	0.2
CV	162,141	49	363	13.8	6,478.9	6,478.9	6,478.9	0.0
CW	162,910	32	295	16.9	6,537.3	6,537.3	6,537.5	0.2
CX	163,833	34	299	16.8	6,608.6	6,608.6	6,608.8	0.2
CY	165,200	34	304	16.5	6,679.2	6,679.2	6,679.2	0.0
CZ	166,325	50	340	14.7	6,743.3	6,743.3	6,743.5	
DA	167,215	67	410	12.2	6,793.8	6,793.8	6,794.2	
DB	168,176	53	348	14.4	6,843.8	6,843.8	6,843.9	
DC	168,874	45	336	14.9	6,876.1	6,876.1	6,876.1	

[1]Feet above confluence with St. Vrain Creek

TABLE 24 — FEDERAL EMERGENCY MANAGEMENT AGENCY — BOULDER COUNTY, CO — AND INCORPORATED AREAS — FLOODWAY DATA — FLOODING SOURCE: BOULDER C

Cross Sections

No cross sections are reported for 1D/2D and 2D floodways. Instead, information is referenced to BFE lines.

LOCATION CROSS SECTION	LOCATION DISTANCE[1]	FLOODWAY WIDTH (FEET)	FLOODWAY SECTION AREA (SQ. FEET)	FLOODWAY MEAN VELOCITY (FEET/ SEC)	1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88) REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
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Data

All data (width, mean velocity, etc.) presented in the 1D/2D FWDT is for the 1D portion only, or for 2D FWDT, for the intersection of the profile baseline and BFE lines only. To get data for any other location in the floodway, the WSEL, velocity, and depth grids should be used.

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Station 45,563-96,222**								

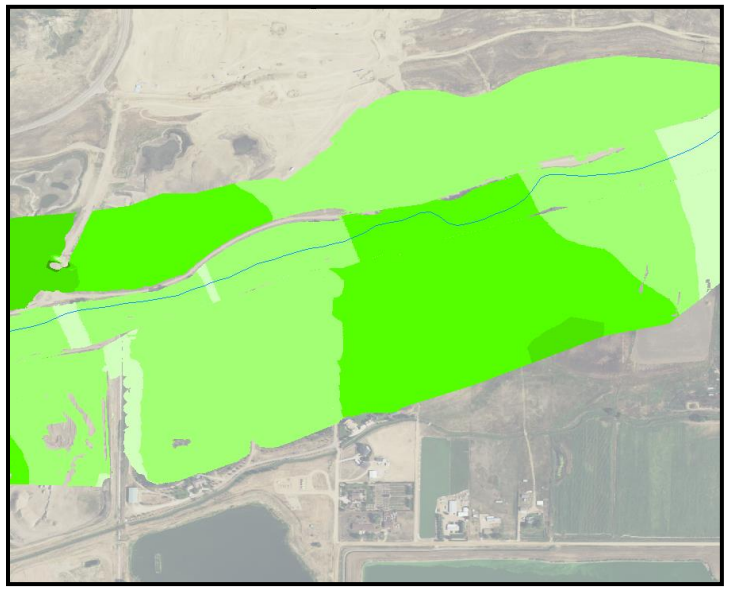
[1]Feet above confluence with St. Vrain Creek
[2]Values computed using a 2D model. Locations are represented by BFEs on the FIRMs. Additional information is available to help determine floodway information including depth and velocity grids. Contact the Boulder County Floodplain Administrator for more information.
*Data not available
**Administrative floodway. Model results not available. Contact the Boulder County Floodplain Administrator for more information.

TABLE 24 | FEDERAL EMERGENCY MANAGEMENT AGENCY | BOULDER COUNTY, CO | AND INCORPORATED AREAS | FLOODWAY DATA | FLOODING SOURCE: BOULDER CREEK

Additional Information for 2D Floodways

- For 1D/2D floodways, information is only reported along the stream centerline for the 1D cross sections (which do not always cover the full floodway). For 2D floodways, information is only available at the intersection of BFE lines and the stream centerline. To find detailed information about specific locations, the surcharge, WSEL, depth, and velocity grids should be used. See the example on Slides 9-12, which is applicable for any grid.

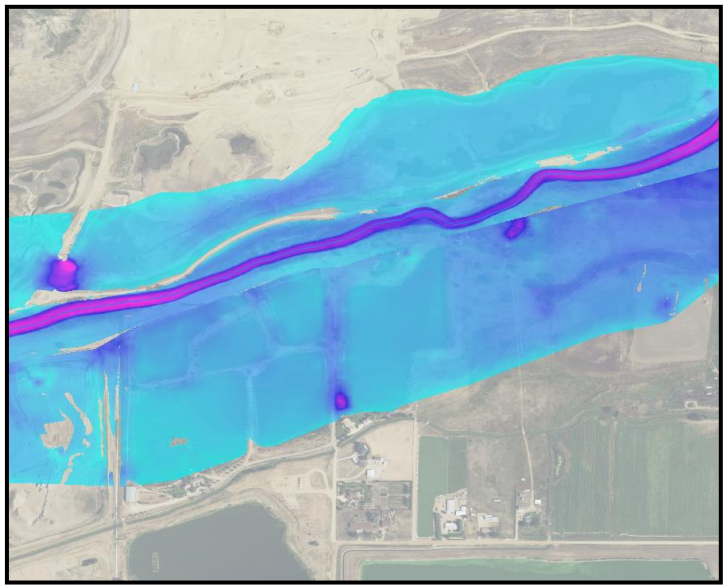
Surcharge



Uses

- Shows the WSEL for the encroached floodplain
- Used to evaluate surcharge at individual properties

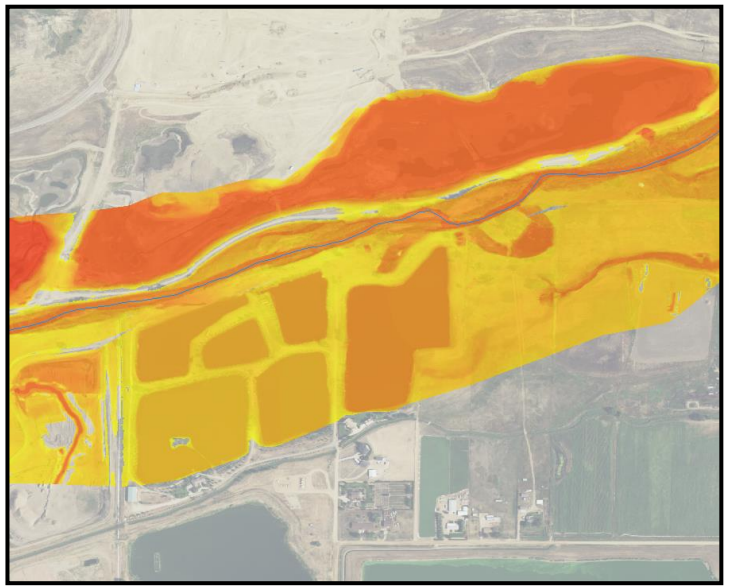
Velocity



Uses

- Supplement for “Mean Velocity’ column in FWDT

Depth



Uses

- Can be used to communicate a depth of floodway at a specific property

Summary

1) 1D/2D and 2D floodways tend to be wider than equivalent 1D floodways due to resolution of the modeling technique.

2) **Management of the floodway is the same for 1D/2D and 2D models**. Floodway boundaries are used to identify areas where development will cause surcharges that do not comply with FEMA/state standards.

3) To assist with management, surcharge, WSEL, depth, and velocity grids are available. For an example of how to use grids in ArcGIS, refer to Slides 9-12.

1D vs. 2D Floodplains: Similarities vs. Differences

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Reasons to Not Have a Floodway

- The floodway concept was developed with 1D analyses in mind, and because of that, current FEMA guidance and standards are written for regulating 1D models.

- **1D/2D and 2D floodways tend to be very wide, which does not allow for much encroachment/development**. No floodway would allow communities to manage development in the floodplain on a case-by-case basis.

- 1D/2D and 2D floodways provide the means to evaluate impacts in more detail than 1D models. As such, managing the floodplain on a case-by-case basis allows communities to take advantage of that higher level of detail.

Managing Without a Floodway

- Managing a floodplain without a floodway requires that an **engineering study be completed every time** proposed development is to occur in the floodplain. In other words, it requires the effective hydraulic model be maintained as a "living" model, constantly being updated as changes occur in your community.

- In addition, managing without a floodway requires that the cumulative impacts of development be tracked from the onset of new FIRM maps being produced to track the total surcharge over time. EXAMPLE

- To track the cumulative impacts of changes in the floodplain, the effective model must be maintained as the base condition for all development.

- No longer use FWDT or FIRM maps as tools for regulating development. All information would be based on the effective model and the products produced from it.

To demonstrate the **difference between managing a floodplain with and without a floodway**, consider the hypothetical case of Floodtown, USA. Floodtown, USA has adopted a 0.5 foot surcharge standard. Floodtown, USA had a floodway delineated on the previous set of effective FIRM maps. In ***Scenario 1***, Floodtown, USA elects to have a 2D floodway delineated on the revised FIRM maps. In ***Scenario 2***, Floodtown, USA does not have a floodway on the new FIRMs due to creation of the new regulatory 2D model. As part of the Floodtown, USA example, consider three events:

Event 1: Release of the new Floodtown, USA FIRM Panels and FIS

Event 2: Construction plans for a new shopping center submitted by Development Co.

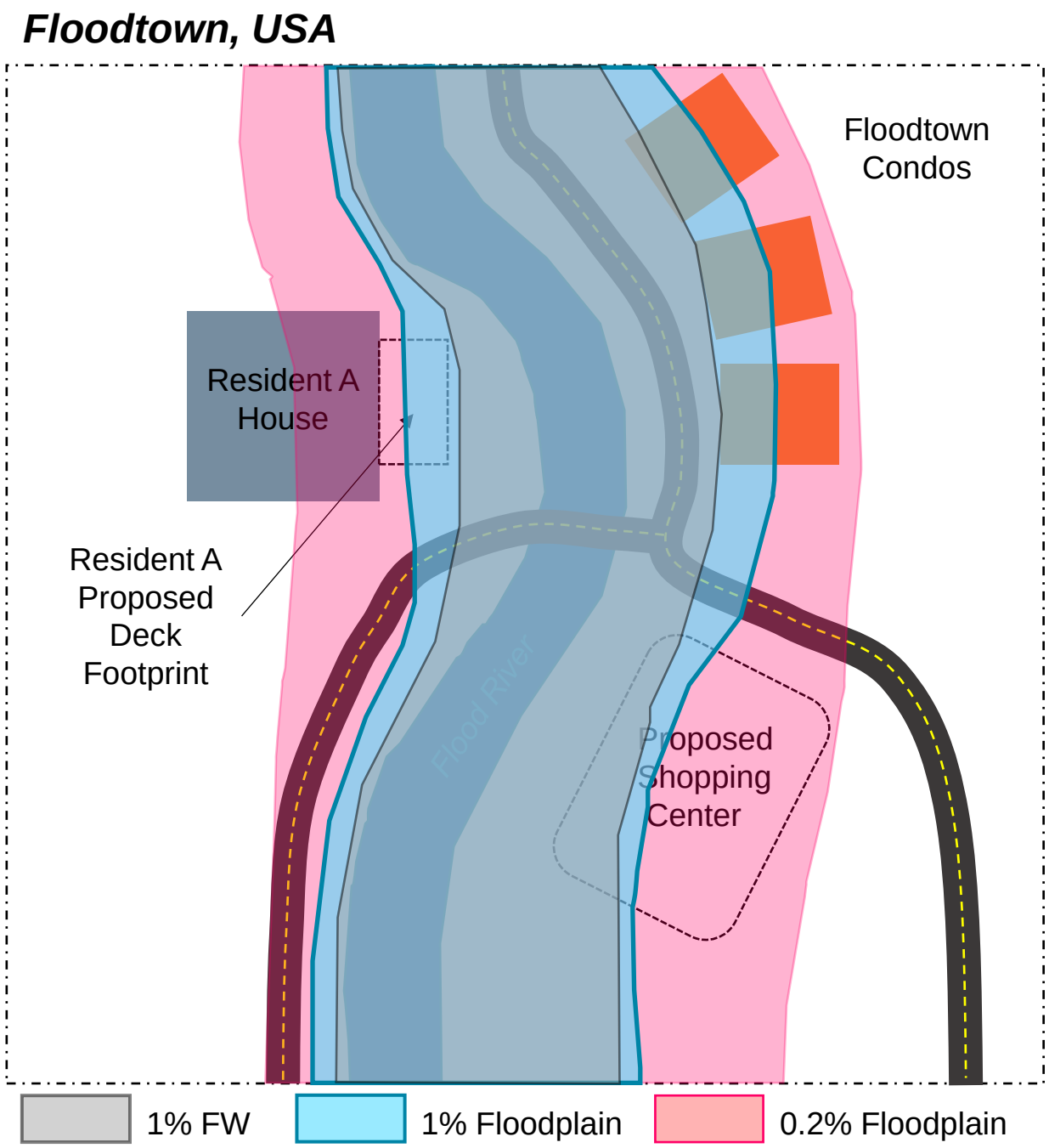
Event 3: Submittal of a building permit by Resident A to construct a new porch for their house

Scenario 1: A 2D Floodway is Delineated on the Revised FIRM Maps

EXAMPLE

Event 1: Release of the new Floodtown, USA FIRM Panels and FIS

Description:
Floodtown, USA's new floodplains just became effective. Included with the floodplains are WSEL, surcharge, depth, and velocity grids generated from the 2D model, as well as a 2D floodway. Development is managed similar to the way it was prior to release of the new FIRMs.

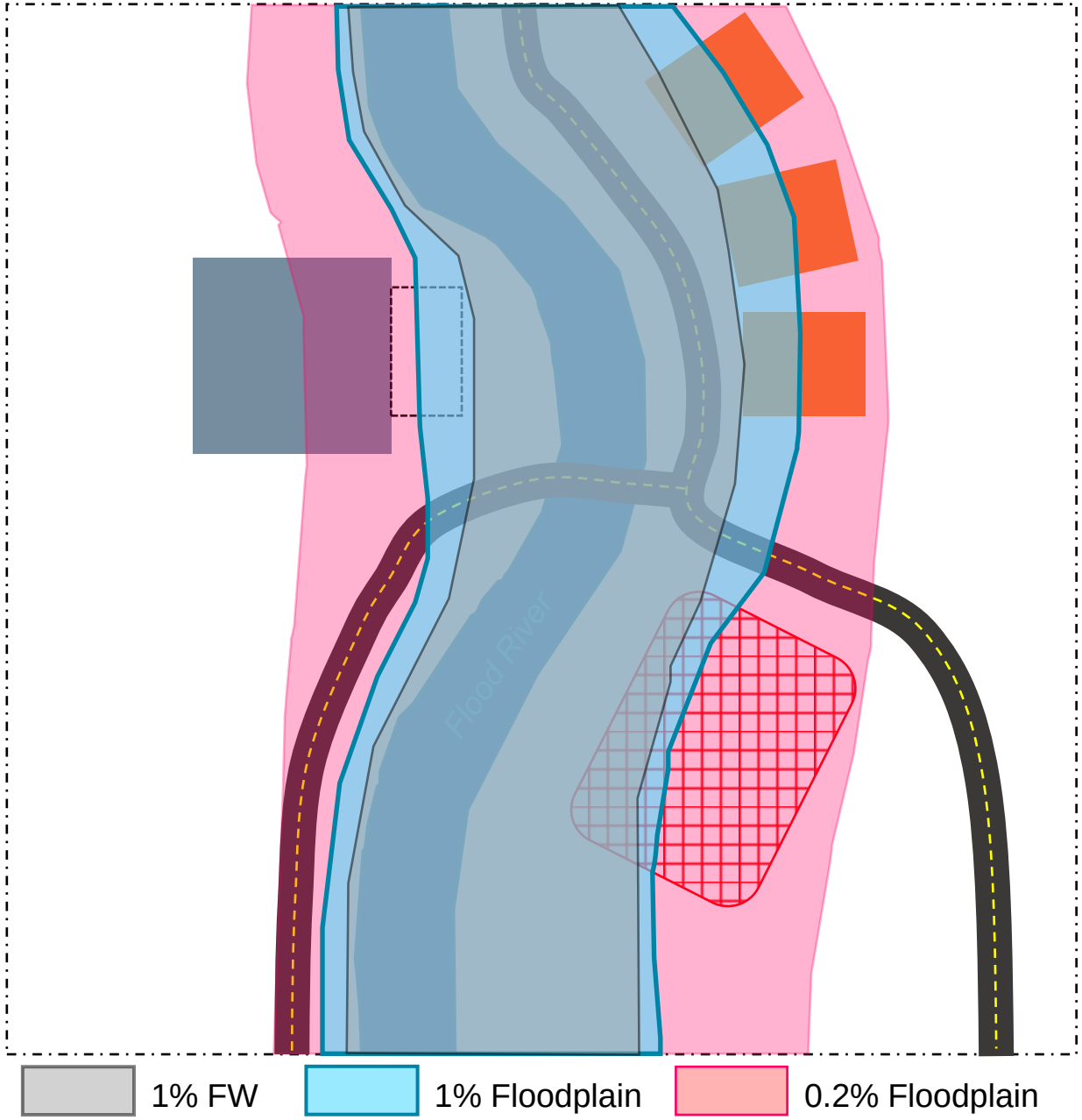


EXAMPLE

Event 2: Construction plans for a new shopping center submitted by Development Co.

Description:
Plans are submitted by Development Co. for construction of a shopping center. The Floodtown, USA Floodplain Manager sees that the proposed footprint of the shopping center development is within the delineated floodway so they tell Development Co. **they must prove a no-rise or development cannot occur**. Development Co. is not able to prove a no-rise so a permit is not issued.

Floodtown, USA

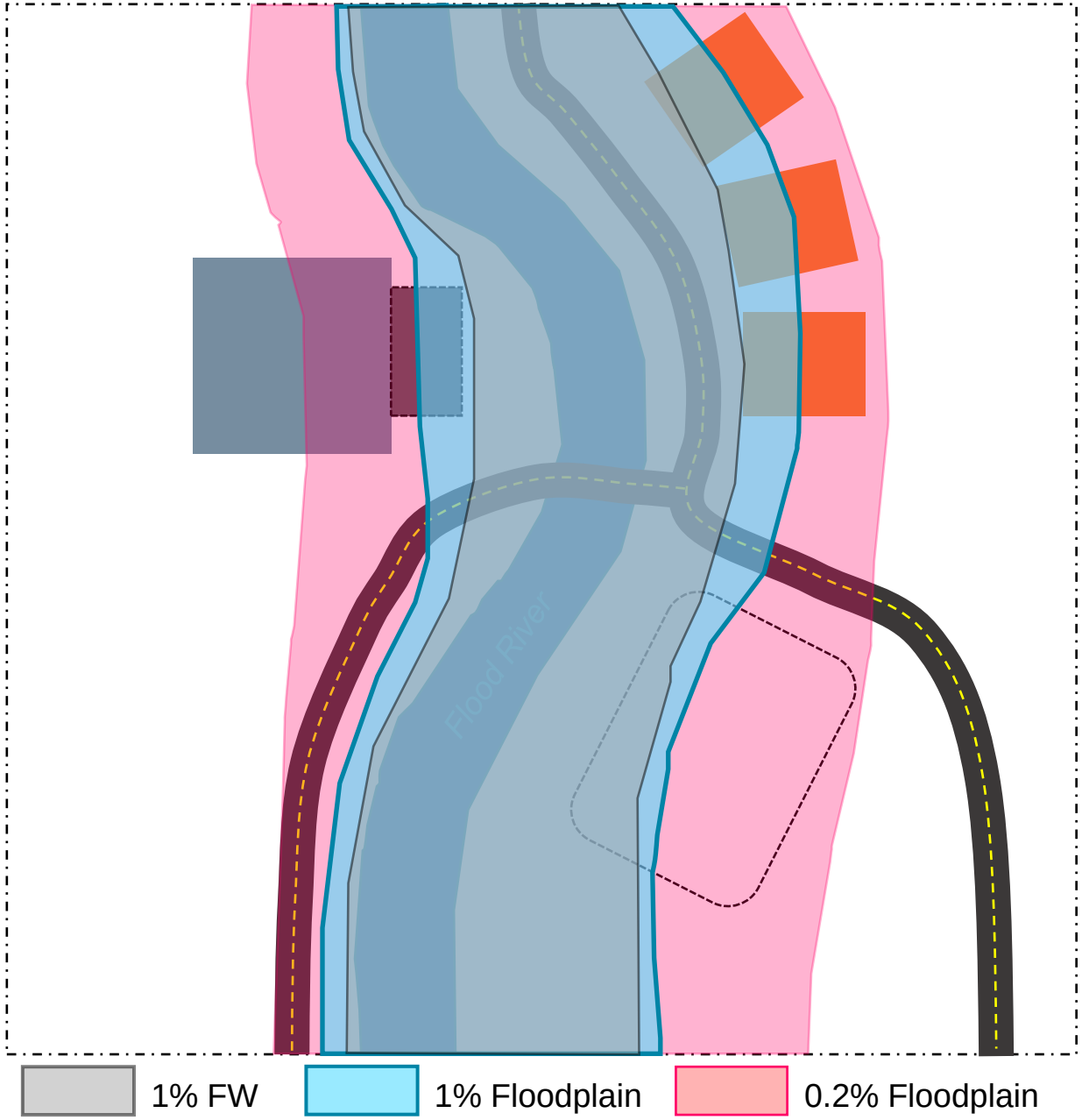


EXAMPLE

Event 3: Submittal of a building permit by Resident A to construct a new porch for their house.

Description:
Resident A submits an application to construct a porch. The Floodtown, USA Floodplain Manager sees that the proposed footprint of the porch is outside of the floodway. As a result, a permit is issued and Resident A proceeds with construction of their porch.

Floodtown, USA

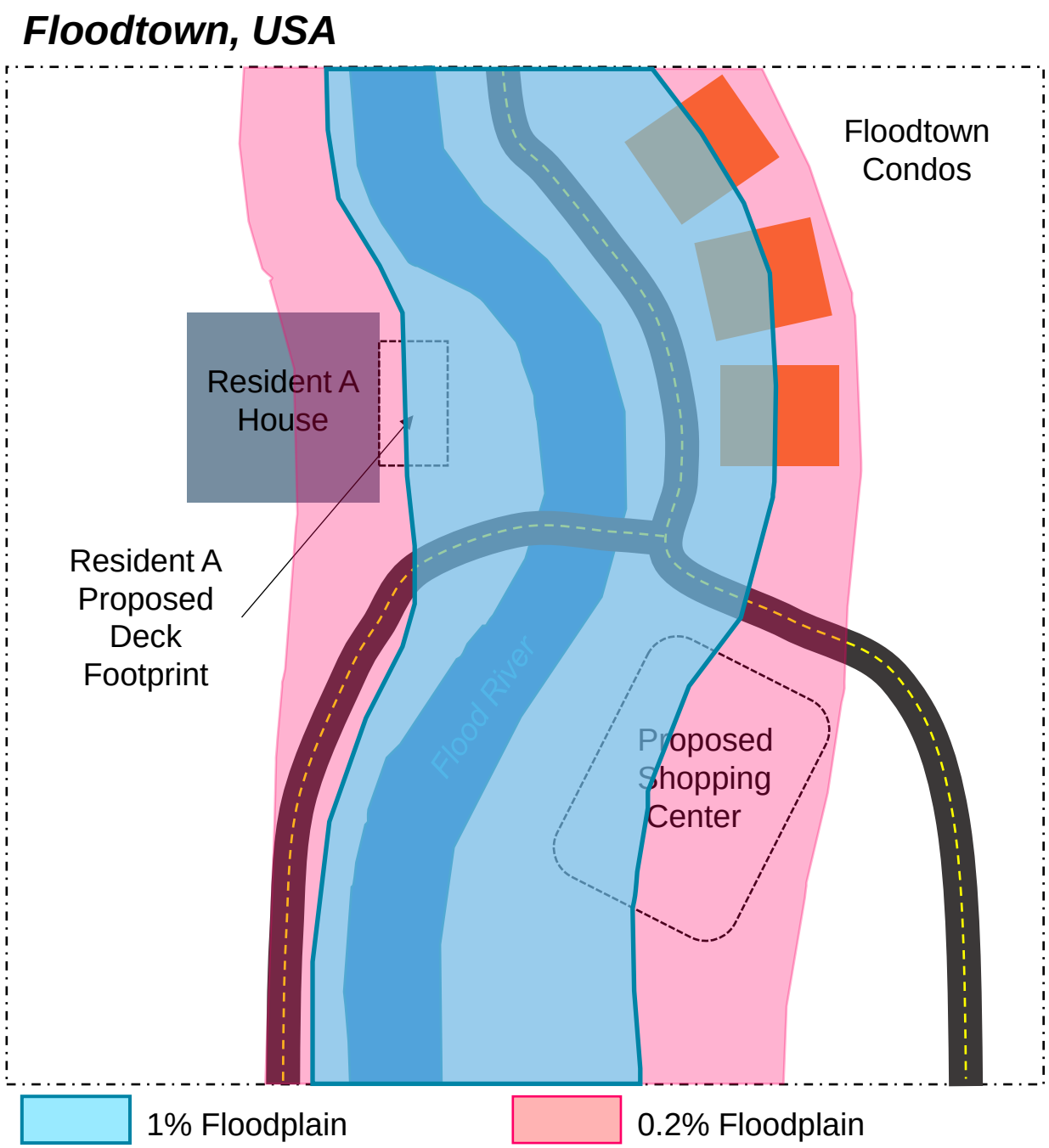


Scenario 2: A 2D Floodway is **not** delineated on the Revised FIRM Maps

EXAMPLE

Event 1: Release of the new Floodtown, USA FIRM Panels and FIS

Description:
Floodtown, USA's new floodplains just became effective. Included with the floodplains are WSEL, surcharge, depth, and velocity grids generated from the 2D model. The WSEL grid generated is now the baseline for all future floodplain development in Floodtown, USA.

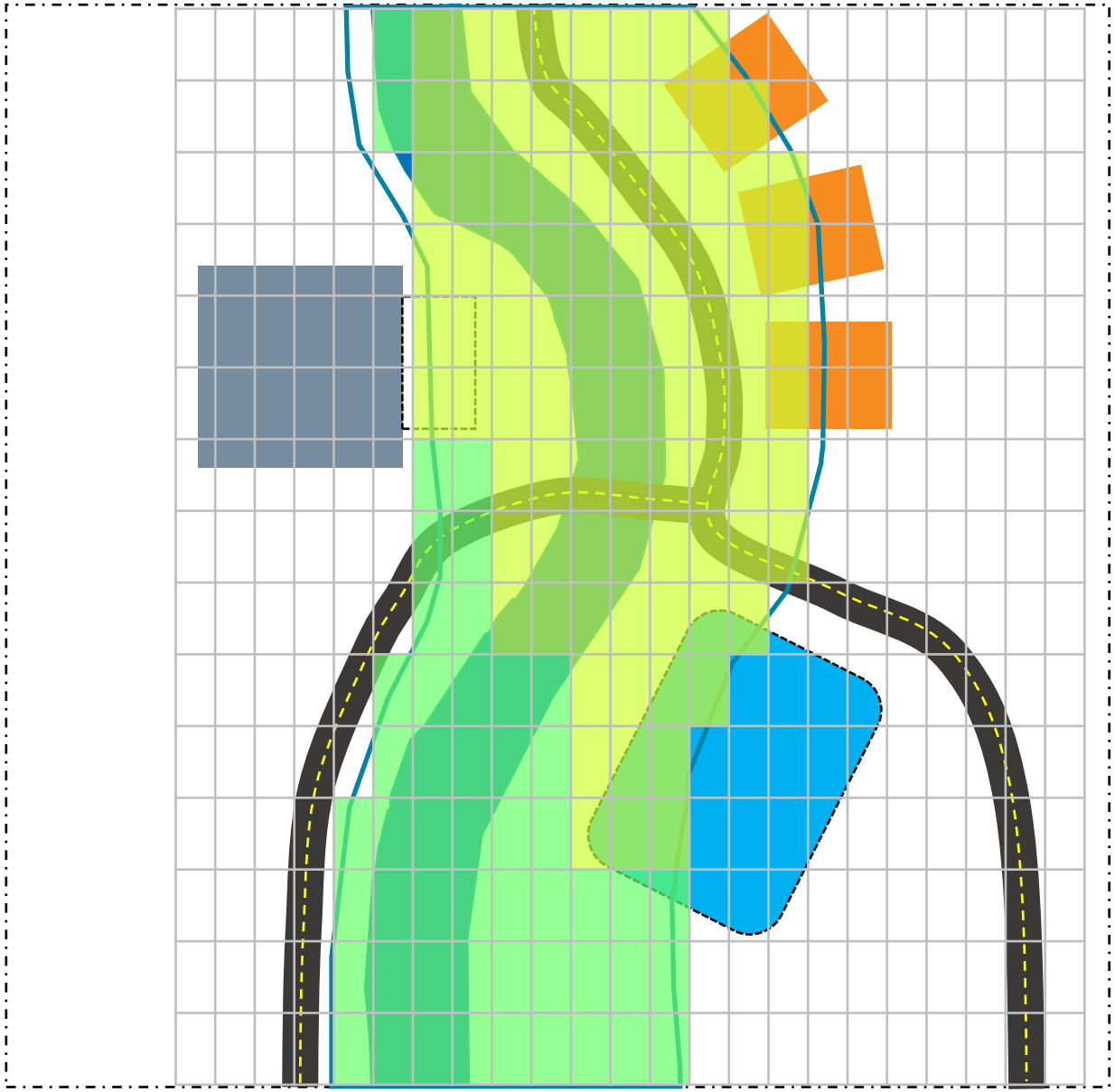


EXAMPLE

Event 2:Construction plans for a new shopping center submitted by Development Co.

Description:
Floodtown Engineering Co. is contracted to study the impacts of the shopping center construction. They find that when compared to the *effective WSEL*, the shopping center does not cause an increase in the WSELs above 0.5 foot and does not cause a shift in the floodplain extents. As a result, the shopping center receives an approved floodplain permit and is constructed.

Floodtown, USA

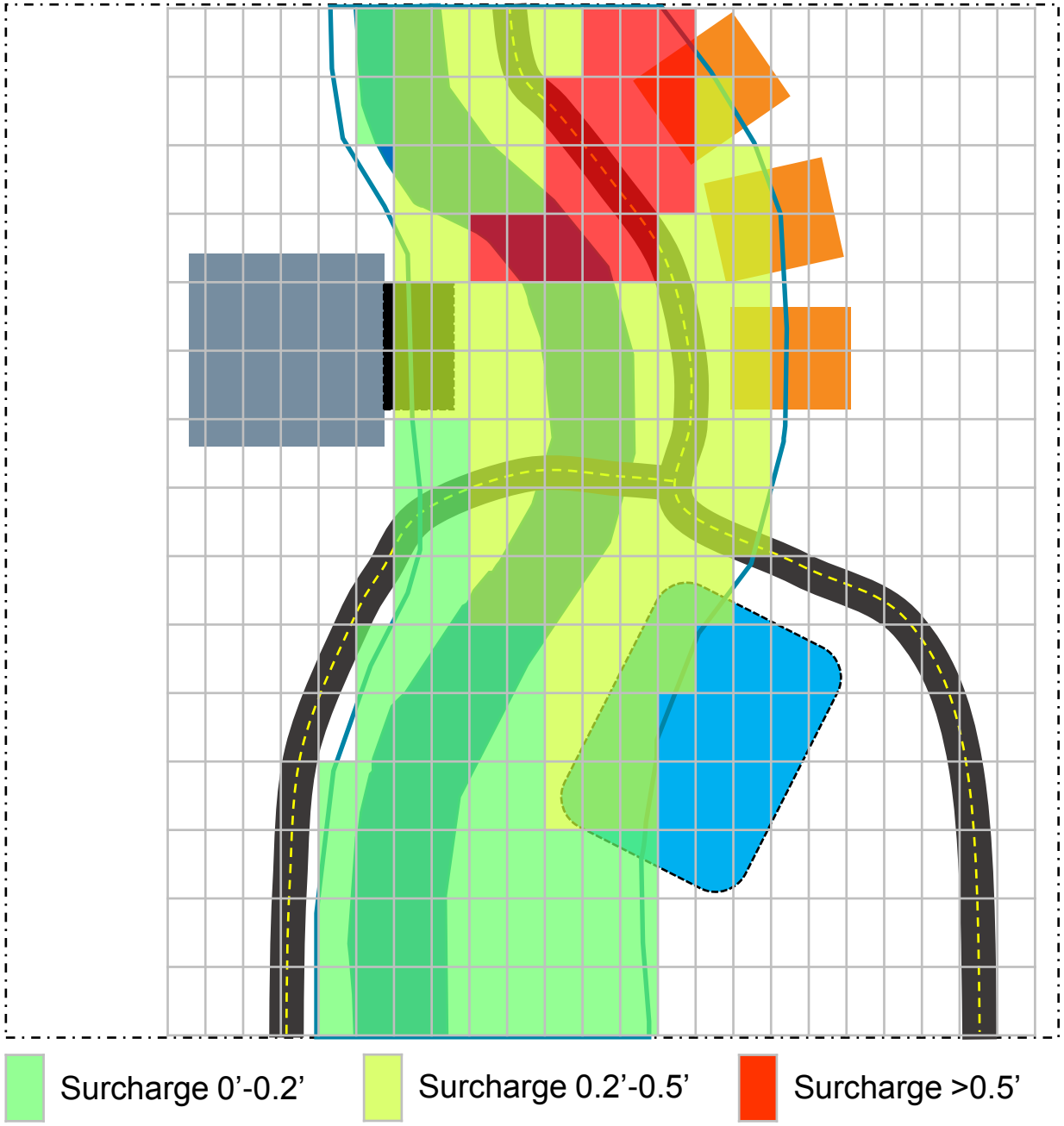


EXAMPLE

Event 3: Submittal of a building permit by Resident A to construct a new porch for their house.

Description:
Floodtown Engineering Co. is hired by Resident A to study the impacts of constructing a porch. The study accounts for the **cumulative development**, that is the proposed porch design plus any change caused by the shopping center construction. They find that compared to the effective WSEL, the deck ***does*** cause an increase in the WSEL above 0.5 foot from the ***effective WSEL grid***. As a result, Resident A's floodplain permit is denied on the basis that it causes an adverse condition downstream.

Floodtown, USA



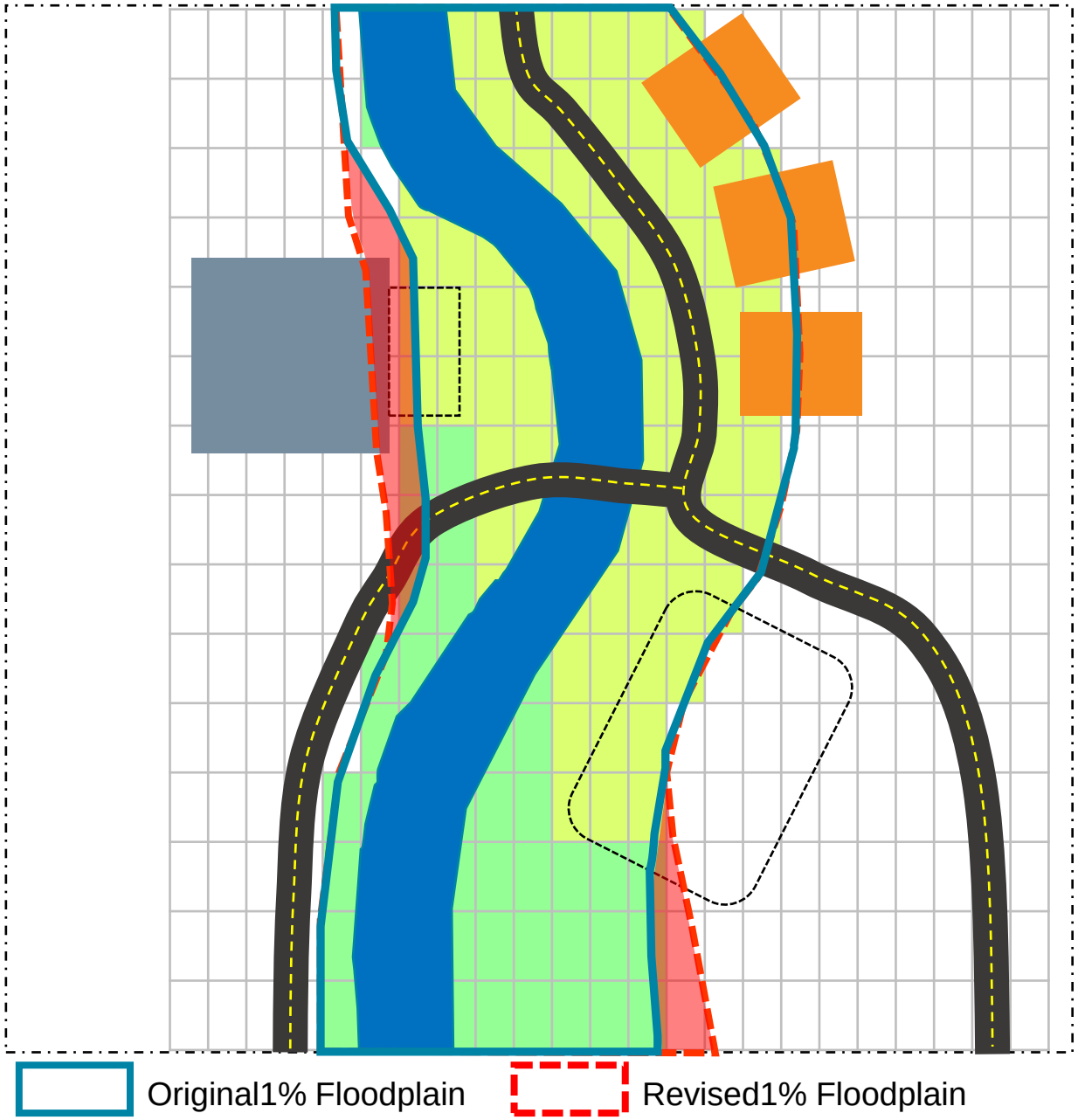
Other Things to Consider

- Equal conveyance is not used in 2D floodway calculations. Therefore, more emphasis needs to be paid to changes in floodplain width based on development in the floodplain. EXAMPLE
- If the floodplain changes as a result of development, a LOMR would be required.
- As in the Floodtown, USA example, someone could develop in the middle of the floodplain and take up all the encroachment potential, eliminating the possibility for others to develop. This introduces a timing component into floodplain development.
- For some communities that zone based on flood risk, rezoning would be required anytime a LOMR is completed.
- Small adjustments to properties (adding a deck, etc.), as well as substantial improvements that do not significantly alter the footprint of a structure may be easier to show no impact. This is because they will not cause a large change in the model.

EXAMPLE

Reconsider Event 2 from the Floodtown, USA example - construction of a new shopping center by Development Co. It may be true that when compared to the *effective WSEL*, the shopping center does not cause an increase in the WSELs above 0.5 foot, but it could **cause a shift in the floodplain due to the additional floodplain obstruction**. If that is the case, a CLOMR/LOMR would need to be completed to determine the revised flooding extents before development can occur.

Floodtown, USA



Summary

1. 1D/2D and 2D floodways tend to be very wide, which does not allow for much encroachment/development.

2. The Code of Federal Regulations has provisions for managing without a floodway. Doing so allows communities to manage development on a case-by-case basis.

3. Managing without a floodway requires additional work and experience. Communities must track the **cumulative impacts of development over time** to ensure WSEL increases, when compared to the effective model, do not exceed the FEMA/state restrictions.

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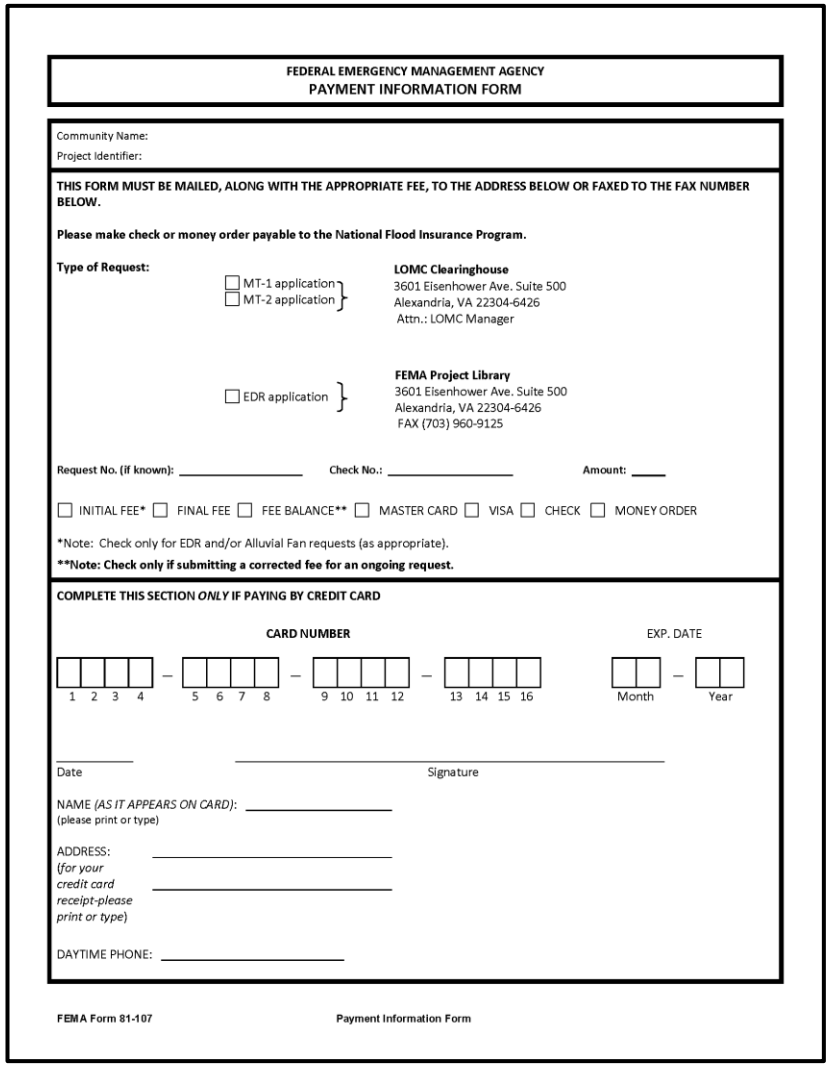
CLOMR/LOMR

- The CLOMR/LOMR process is the same for either a 1D, 1D/2D, or 2D model.
  - Still follow MT-2 procedures
  - Same fees

- CLOMR/LOMR can be completed using various modeling techniques as long as the CLOMR/LOMR ties-in with the effective data (i.e. 1D CLOMR/LOMR completed in area with 2D model); however, **communities should strive to maintain a continuous model.**

- Requires consultants to have familiarity with 2D techniques.

- CLOMRs/LOMRs may be required more often when using 1D/2D or 2D models because the models show more detail.



FEDERAL EMERGENCY MANAGEMENT AGENCY
PAYMENT INFORMATION FORM

Community Name:
Project Identifier:

THIS FORM MUST BE MAILED, ALONG WITH THE APPROPRIATE FEE, TO THE ADDRESS BELOW OR FAXED TO THE FAX NUMBER BELOW.

Please make check or money order payable to the National Flood Insurance Program.

Type of Request:

☐ MT-1 application
☐ MT-2 application

LOMC Clearinghouse
3601 Eisenhower Ave. Suite 500
Alexandria, VA 22304-6426
Attn.: LOMC Manager

☐ EDR application

FEMA Project Library
3601 Eisenhower Ave. Suite 500
Alexandria, VA 22304-6426
FAX (703) 960-9125

Request No. (if known): _____ **Check No.:** _____ **Amount:** ____

☐ INITIAL FEE* ☐ FINAL FEE ☐ FEE BALANCE** ☐ MASTER CARD ☐ VISA ☐ CHECK ☐ MONEY ORDER

*Note: Check only for EDR and/or Alluvial Fan requests (as appropriate).
****Note: Check only if submitting a corrected fee for an ongoing request.**

COMPLETE THIS SECTION *ONLY* IF PAYING BY CREDIT CARD

CARD NUMBER EXP. DATE

☐☐☐☐ – ☐☐☐☐ – ☐☐☐☐ – ☐☐☐☐ ☐☐ – ☐☐
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 Month Year

_____ _____
Date Signature

NAME *(AS IT APPEARS ON CARD)*: _____
(please print or type)

ADDRESS: _____
(for your credit card receipt-please print or type) _____

DAYTIME PHONE: _____

FEMA Form 81-107 **Payment Information Form**

No-Rise Certifications

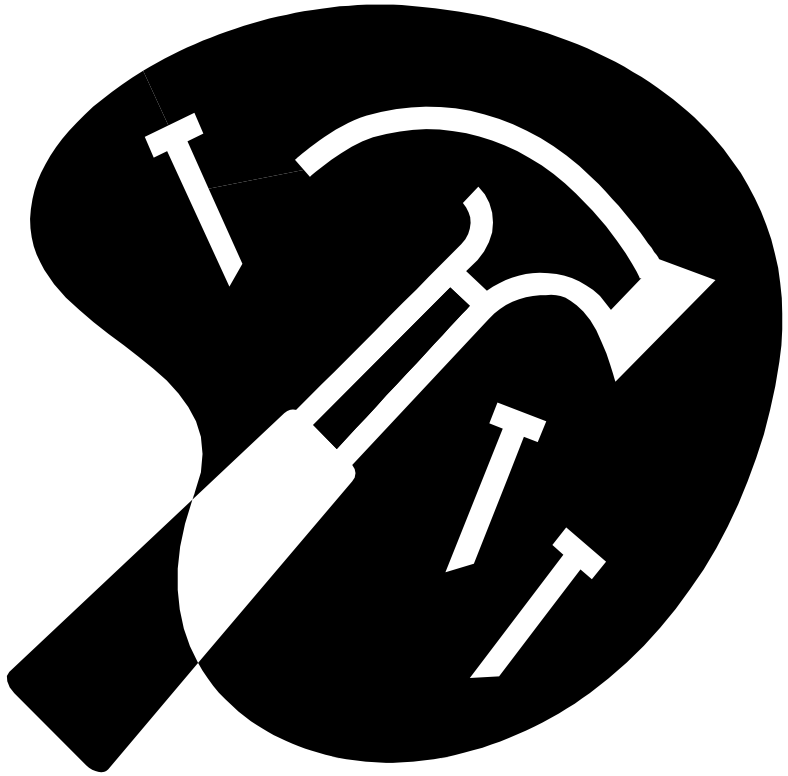
- No-Rise conditions are more difficult to prove when referenced to 1D/2D or 2D models.

- Similar to the discussion of 2D floodways, each cell must meet the no-rise criteria, as opposed to 1D models where the no-rise criteria only needs to be satisfied at each cross section. In a typical 1D/2D or 2D model, there are 10,000s of locations that must satisfy the no-rise standard versus a 1D model where there are 10s or 100s.

Floodplain Permits

- Floodplain Permits operate the same for 1D, 1D/2D, or 2D models.

- When issuing Floodplain Permits where the floodplain is being managed with no floodway, must keep cumulative impacts of development in mind to ensure no adverse condition is created. See the example on Slides 28-31.



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What are the benefits of 2D models?

Advantages

- Better represents complex flooding scenarios such as:
  - Split flows
  - Urban flooding
- Provides more detailed output information than 1D models such as Depth x Velocity grids, etc.
- Can be used to inform 1D models

Disadvantages

- Current regulatory floodplain standards are setup for 1D models
- Software can often be expensive
- Less universally understood. Can be difficult to maintain and use 2D results
- Run times for long/complex models

Open Source vs. Paid Software?

Open Source

- More accessible for future use
- Increases possibility that 2D will continue to be used in the future
- Likely to gain larger user base as popularity of 2D advances

BUT

- Less support available
- Fewer capabilities

Paid

- Capabilities often exceed that of open source
- Better support systems for model issues

BUT

- Tends to have smaller user base due to price of software
- May restrict future use

For Additional Information or Questions, See Contacts Below

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