W e t l a n d s   A n a l y s i s

FOR Save the Poudre: Poudre Waterkeeper | BY PetersonGIS

Inputs, Methods, Results

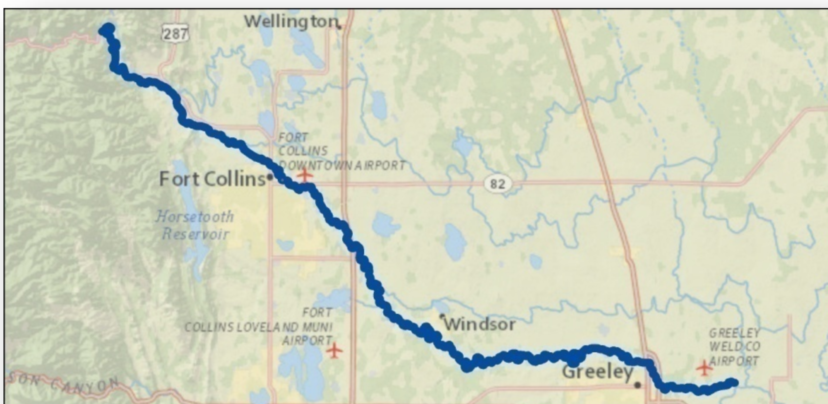
June 15, 2012

PROJECT GOALS

The project goals were 1) create variable width buffers along the Cache la Poudre River that represent half-foot increments in elevation change between the river streamline and the outer edge, from half-foot to ten feet and 2) calculate the total wetland area of each wetland type within each buffer.

STUDY AREA

The study area was the Cache la Poudre River, from its confluence with the North Fork Cache la Poudre River to its confluence with the South Platte River, as shown in dark blue, below.



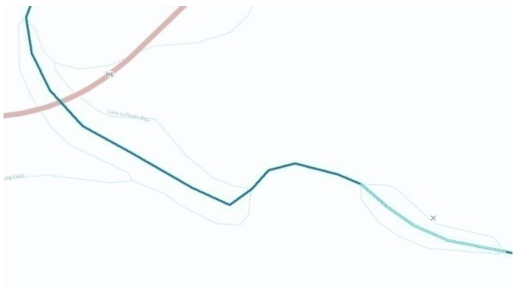
DATA

Elevation The 10 meter resolution National Elevation Dataset (NED) was used. The elevation values are in meters, with high precision (6 decimals). The data was mosaicked into a single grid. The data was then converted to an integer grid by multiplying the elevation values by 100, since an integer grid—rather than a floating point grid—was required in some of the GIS processing steps.

Streams Hydrography centerline data for the study area were received from the City of Greeley GIS Department and the Larimer County GIS Department. A few sections of the river were digitized by-eye using an Esri topography basemap at 1:5,000 scale. The sections where this was necessary were 1) a location where there was a gap in the hydrology and 2) a few small places where the original hydrography represented the outer banks of ponds rather than the centerlines.

1) Gap digitizing location shown by red arrow:

2) Stream centerline digitizing shown below:



Wetlands Wetlands data were received from Save the Poudre: Poudre Waterkeeper. Though the original wetland data extent included wetlands for portions of the South Platte River, these were excluded from the analysis as they were not in the study area. Identification of which wetlands were to be excluded was determined by eye. Where the Cache la Poudre River meets with the South Platte River, the South Platte River wetlands were identified and eliminated from processing by estimating the correct wetland connectivity from a hillshade basemap.

DATA ACCURACY

NED The NED has a reported 90% vertical accuracy confidence of 3.99 meters and 95% vertical accuracy confidence of 4.75 meters. This accuracy is for the coterminous U.S. The accuracy within the Save the Poudre: Poudre Waterkeeper study area may be more or less. However, it is reasonable to assume that while the absolute accuracy may be plus or minus 4 meters, it is also reasonable to assume that the accuracy between nearby pixels is much better; in other words, the level of incorrectness—precision—would be relatively consistent across a study area as small as this (small when compared to the coterminous U.S.).

Streams The stream data do not have a reported accuracy. However, the accuracy appears to be at least consistent with a map scale of 1:5,000.

Wetlands The wetlands polygons used in this study, and their associated methods and accuracy are described in *National Wetland Inventory (NWI) Mapping of the Cache la Poudre and South Platte Rivers*, Colorado Natural Heritage Program, Colorado State University, March 23, 2011.

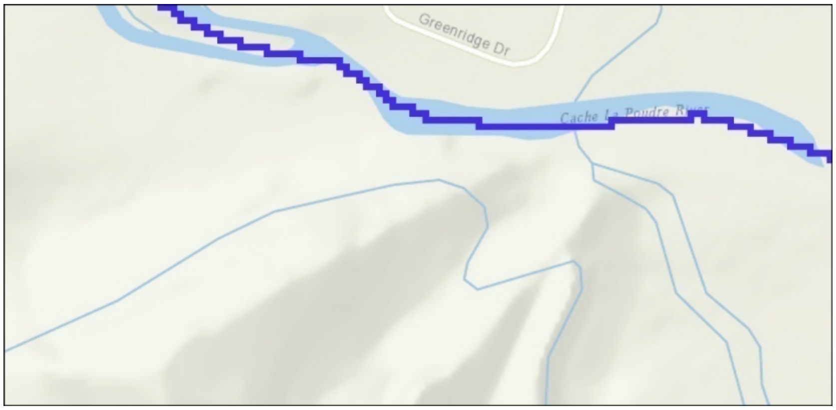
CALCULATING ELEVATION INCREMENT BANDS

The methods for creating the elevation increment bands are as follows. These steps illustrate the creation of the 3 foot buffer, as an example of creating any one elevation zone. The entire dataset is not shown, but rather zoomed into a segment of the river to better illustrate the process. The zoomed-in portion of the map used for the illustrations is shown outlined in a black rectangle in the following overview map:

The last step of the procedure was repeated, with the increment number (15 for 0.5', 30 for 1.0', 45 for 1.5' and so on) changing each time

1) The procedure began with a vector representation of the Cache la Poudre River centerline shown here as a dark blue line overlaid on a basemap:

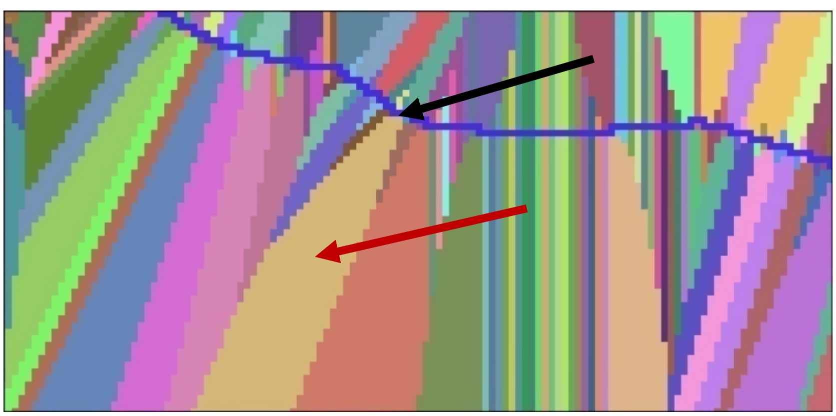
2) The vector river centerline was converted to a 10 meter resolution grid, where each grid cell was assigned the elevation of the NED at that location. The river centerline grid was the same size and extent as the NED, so that the grid cells were exactly aligned between the two datasets. The centerline grid is shown in purple:



3) Using the river centerline grid as the source grid, a Euclidean allocation grid covering the study area was created. In a Euclidean allocation operation, the software creates a new grid and, for each cell, determines which source cell (the closest river cell in this case) it is closest to and then assigns the value of that nearest cell to it.

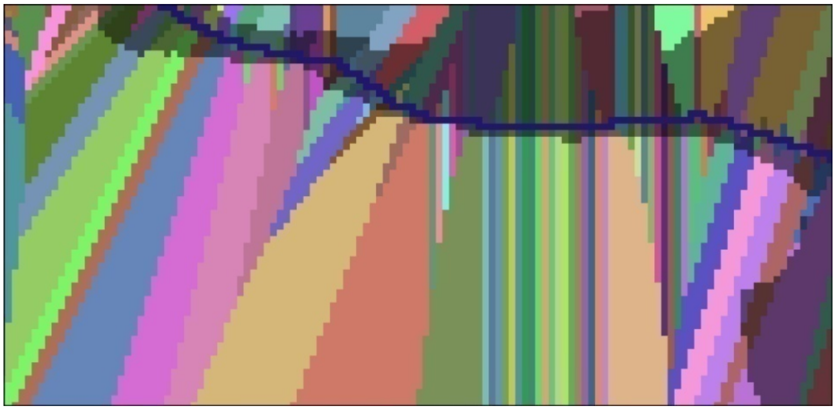
In doing this, the software will later be able to determine which starting elevation value to compare each cell to, in order to determine if each cell is within the three foot limit or not. The resulting grid is colored such that each color represents a different elevation value. It is easy to see from the illustration how the elevations are allocated outward from the source cells according to which source cell each is closest to.

For example, the black arrow points to one source cell with an elevation value of 154600 (this number represents meters, multiplied by 100). The red arrow points to the Euclidean allocation of all the other cells that were assigned 154600—in the tan section—because they were closest to that source cell.

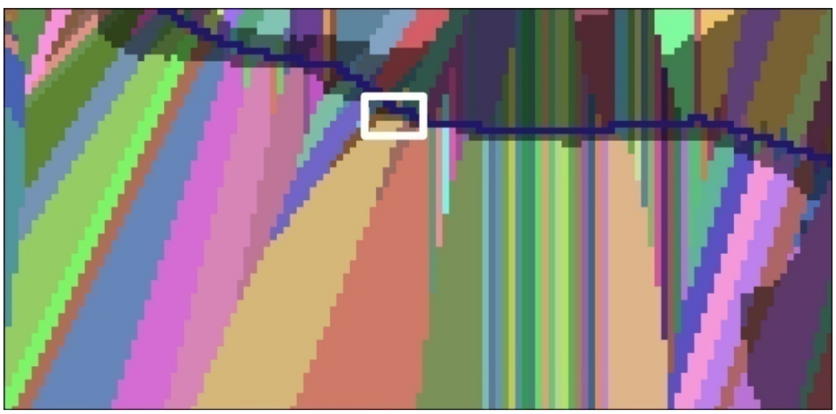


4) To delineate the 3 foot elevation increase buffer, for example, the elevation values of all the non-river cells need to be compared to the elevation values of their closest river cells. To do this, the software was programmed to subtract the Euclidean allocation grid from the original NED grid and determine whether the difference is greater than 3 feet or less than or equal 3 feet. Cells where the difference was less than or equal to 3 feet were included in the final buffer, the others were not.

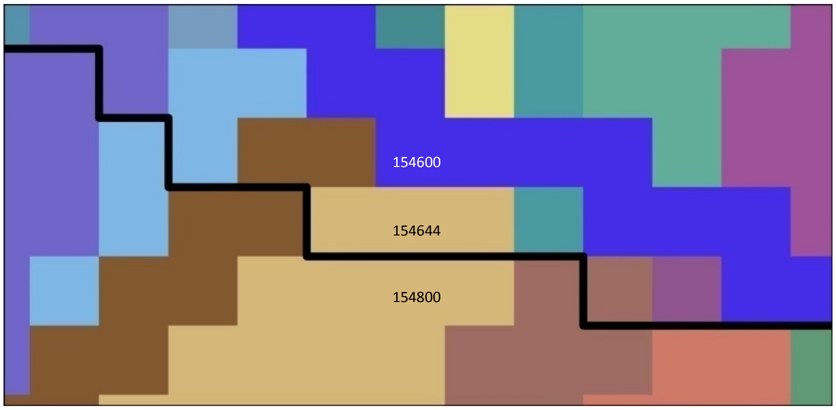
The 3 foot elevation increment buffer is shown below, in semi-transparent black.



To further illustrate the process, the map was zoomed-in to the area shown in the white rectangle below:



In the zoomed-in map, the 3 foot buffer is shown as a dark black line. The river source cell is labeled in white with its elevation value of 154600. The elevations of two nearby cells are labeled in black. Both of the nearby cells that are labeled are closest to the 154600 source cell. However, the 154800 cell is more than 3 feet above the source cell: 154800 – 154600 = 200, where 200/100 x 3.28 = 6.56 feet, which is above the 3 foot threshold for this elevation buffer. For the cell above it: 154644 – 154600 = 44, where 44/100 x 3.28 = 1.44 feet, which is within the 3 foot threshold for this elevation buffer.

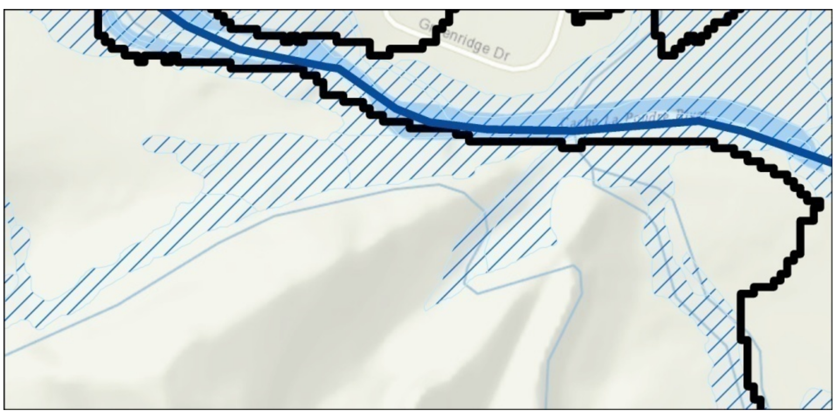


This step was repeated for all the elevation increments from half-foot to ten-feet, thus creating 20 progressively larger elevation increment buffers.

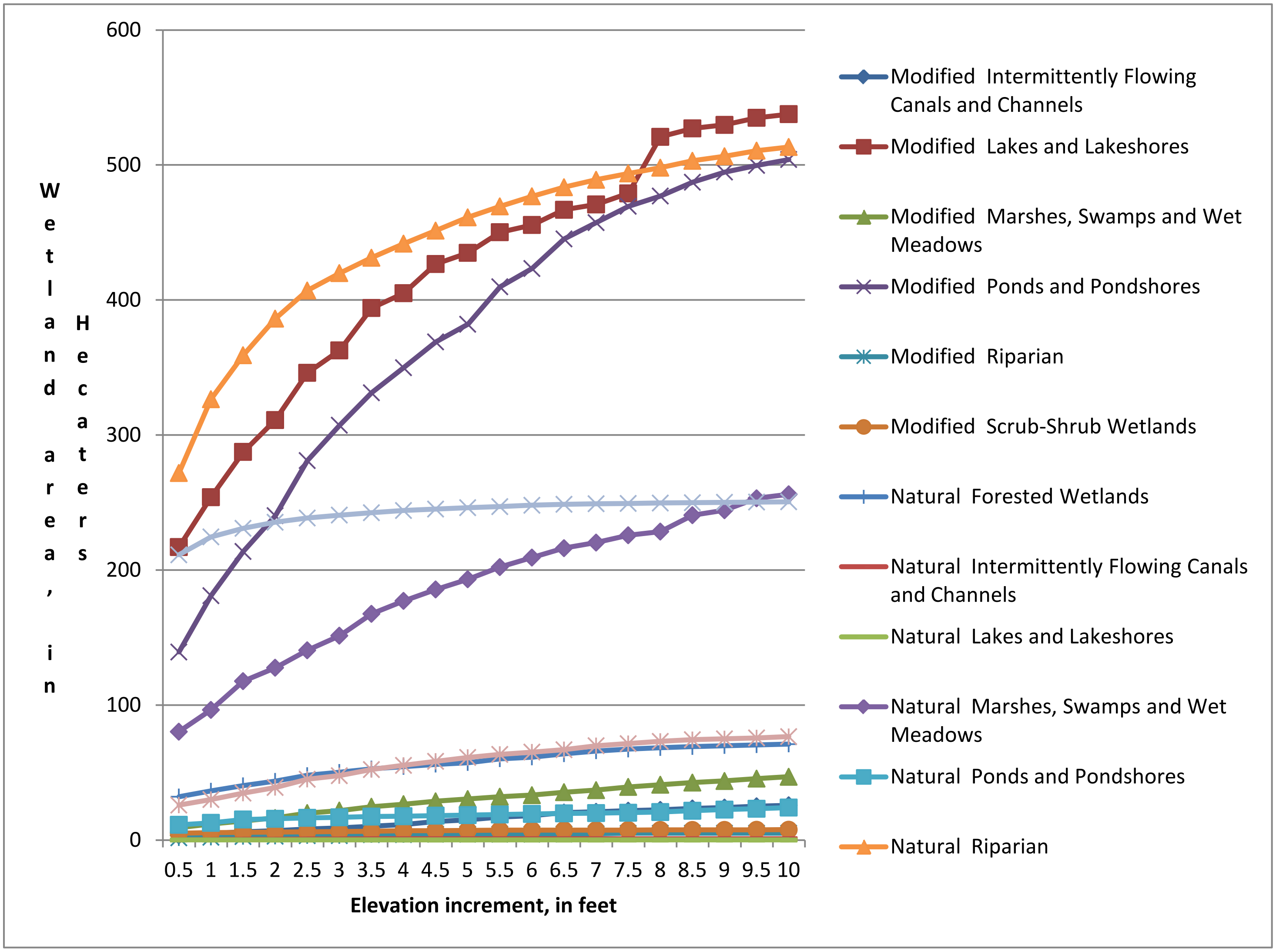
WETLAND AREA CALCULATIONS

The area of wetlands within each elevation increment buffer was computed with a zonal statistics operation. The operation sums the total area of wetlands, per each wetland category, in each elevation increment buffer. The following map shows the 3 foot elevation increase buffer as a black outline, the Cache la Poudre River as a dark blue line, and the wetlands—all wetland types shown as a blue-hatched area. For the 3 foot elevation increment buffer, only the blue-hatched area within the black line was counted.

The graph and table shown in this section report the wetland areas in hectares.



WETLAND AREA RESULTS



	Elevation increment, in feet									
Wetland Type	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Modified Intermittently Flowing Canals and Channels	3.63	5.01	6.1	7.12	8.31	9.17	10.28	11.65	13.85	14.96
Modified Lakes and Lakeshores	217.1	254.01	287.57	311.14	346.12	362.73	394.14	405.1	426.7	434.98
Modified Marshes, Swamps and Wet Meadows	9.26	11.87	14.22	16.42	20.1	21.95	24.79	26.7	28.78	30.44
Modified Ponds and Pondshores	139.35	181.07	213.83	240.34	281.13	307.32	331.34	349.91	369.02	382.08
Modified Riparian	1.75	2.16	2.7	2.93	3.35	3.38	4.09	4.12	4.46	4.46
Modified Scrub-Shrub Wetlands	5.16	5.48	5.78	5.99	6.24	6.48	6.63	6.95	7.12	7.26
Natural Forested Wetlands	32.19	36.45	40.46	43.74	47.99	50.34	52.87	54.45	56.16	57.36
Natural Intermittently Flowing Canals and Channels	0.29	0.48	0.63	0.67	0.81	0.83	0.94	0.95	0.98	1.03
Natural Lakes and Lakeshores	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Natural Marshes, Swamps and Wet Meadows	80.35	96.48	117.77	127.72	140.63	151.45	167.62	177.22	185.69	193.23
Natural Ponds and Pondshores	11.4	12.85	15.34	15.84	16.57	16.95	17.48	17.74	18.17	18.57
Natural Riparian	271.92	326.56	359.15	386.25	407.06	419.96	431.34	441.79	451.43	461.25
Natural Rivers/Riverbanks and Stream/Streambanks and Bars	211.32	224.61	230.95	235.45	238.6	240.76	242.51	244.15	245.22	246.24
Natural Scrub-Shrub Wetlands	25.97	30.09	34.84	39.05	45.13	47.75	52.29	55.4	58.4	61.28

	Elevation increment, in feet									
Wetland Type	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
Modified Intermittently Flowing Canals and Channels	17.07	18.09	20.45	20.98	21.81	22.4	23.46	24.12	25.09	25.85
Modified Lakes and Lakeshores	450.26	455.62	466.86	470.82	478.99	520.87	527.15	529.73	534.98	537.71
Modified Marshes, Swamps and Wet Meadows	32.21	33.33	35.56	37.07	39.46	41.07	42.66	43.83	45.61	46.96
Modified Ponds and Pondshores	409.85	423.36	445.29	457.35	469.46	477.05	487.26	494.83	499.73	504.11
Modified Riparian	4.46	4.46	4.61	4.75	5.06	5.13	5.17	5.17	5.17	5.17
Modified Scrub-Shrub Wetlands	7.34	7.38	7.42	7.47	7.51	7.54	7.56	7.6	7.7	7.74
Natural Forested Wetlands	60.16	61.49	63.86	66.06	67.35	68.45	69.2	69.95	70.57	71.11
Natural Intermittently Flowing Canals and Channels	1.05	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Natural Lakes and Lakeshores	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Natural Marshes, Swamps and Wet Meadows	202.24	209.29	216.25	220.39	225.83	228.54	240.68	244.35	253.19	256.17
Natural Ponds and Pondshores	19.05	19.45	19.87	20.07	20.32	20.84	21.8	22.65	23.28	24.17
Natural Riparian	469.38	476.85	483.55	489.06	493.79	498.04	503.12	506.5	510.67	513.37
Natural Rivers/Riverbanks and Stream/Streambanks and Bars	247.02	248.02	248.75	249.17	249.38	249.67	249.92	250.23	250.41	250.61
Natural Scrub-Shrub Wetlands	63.52	65.24	66.99	69.96	71.49	73.15	74.42	75.06	75.74	76.69

OTHER METHODS

Other methods that are similar to the methods described in this paper include the following. These other methods were explored but ultimately not used for the reasons discussed:

Cost Distance The cost distance tools in GIS software are sometimes used to simulate floods, a similar goal to the one in this analysis (see descriptions on how this works here and here). In order to use the cost distance method, a stage surface elevation is needed. The stage surface elevation in this analysis' study area, however, varies as the terrain decreases downstream. As stated in the second article linked to above, the cost distance flood simulation process is a local level procedure and not applicable for a larger study area like the one in this analysis.

Transect Points As described here, a method of deriving transect points that emanate from stream centerline points has been used for modeling of riparian zones using digital elevation models and flood height data. In this method, the elevation values at points along transects are compared with the elevation values at the stream points that the transects emanate from. If they are above the user-set threshold then those points are not within the buffer. Points that are within the threshold are then connected to form the buffer. This procedure has the potential to create larger buffers because each cell is considered with more than a single source cell (the transects overlap), whereas the procedure in this analysis compared each cell to its single closest source cell. The Save the Poudre: Poudre Waterkeeper analysis is a more conservative estimate of the buffer than the transect points procedure.

Lake and Pond Amendment The Save the Poudre: Poudre Waterkeeper analysis could have been less conservative if the buffers were augmented with an existing lake and pond data layer. As it is, the buffers sometimes split lakes and ponds.

MODELING ACCURACY

Potential sources of inaccuracies, listed below, all point to the fact that this analysis is conservative in its identification of the elevation increment buffers. The buffers represent, as far as it is known, the smallest possible area within which the specified elevation increments occur.

Source Cells In this analysis, the source cells consisted of a one-cell-wide representation of the Cache la Poudre River centerline. Another possible source cell representation would have been to widen the centerline to two or more pixels, or to use river bank cells. Any of these possibilities would have increased the original elevation that all elevations were compared to, thus widening the resulting buffers. With regard to source cells, the one-cell-wide representation used in the study contributed to the conservative size (small, rather than including potentially inaccurate cells) of the buffers.

The river centerline locations posed a potential for inaccuracy. The location of the river centerline determines the source elevations that all other cells are compared to. However, the river centerlines were a higher resolution (1:5,000) than the NED data they were being compared to and converted to (10-meter).

The model only considers the closest source cell when comparing whether or not an elevation is above the elevation increment buffer threshold or below it. Source cells that are second-closest to comparison cells are not considered. Therefore, a situation can occur where a pixel that is diagonal—in the southeast direction, for example—to a source cell may have been within a half-foot from the northwestern source cell, but is not within half-foot from its closest cell—the one directly to the west of it. In this example case, the northwestern pixel would have to be a greater elevation than the western pixel (entirely possible given the downward nature of the river terrain). This example is shown below. The source cells are indicated in the shaded gray boxes. The cell with elevation of 154614 is within half-foot of the cell with elevation value 154600, but not within half-foot of the cell with value 154595.

154600	154620
154595	154614

Elevation units are in meters x 100

In this way, the resulting elevation increment buffers are conservative, and not as large as they might be if second-closest cells were also considered.

Euclidean Algorithm The Euclidean allocation algorithm has a potential source of error worth noting but is most likely insignificant across the study area. In cases where a pixel is equidistant between two source pixels, the algorithm assigns that pixel the elevation value of the first of the two source pixels that it encounters, and is basically arbitrary in these cases. Because the source river cells are only one-pixel wide, this occurs rarely.