Studying of Average rainfall within two of the Subwatershed of the Willamette River Basin system

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Introduction.

In Oregon State the amount of rainfall plays huge role regarding actual amount of water within individual watershed in Oregon.

In particularly, Willamette watershed/basin is important because of many criteria such as

- contain the most important cities in Oregon regarding the areas such as Portland , Eugene, and Salem (Taylor, 1993).
- In these biggest cities, population are relatively high. Therefore, more research should be conducting for this area (Taylor, 1993).
- The moisture throughout the year makes it ideal region for a various agricultural application. Some of the agricultural products produced within the Willamette Valley includes high quantities are tree fruits, nuts, berries, mint, grains, and hay (Taylor, 1993)

In addition, this river basin is also one of the river basins in Oregon with the highest amount of rainfall. At any watershed area around Oregon state. Therefore, for this project I will mainly focus on two Subwatershed within Willamette River as a case of rainfall effecting on watershed. These two-Subwatershed called Pudding Subwatershed and Keizer Subwatershed

Why someone would be interested.

Since my focus is in two Subwatershed one is located in residential area and the other is in rural area.

- In urban area it can give information about urban flooding, this information can be helpful to city planners for mitigation urban floods creating drainage for the urban areas and for proper urban planning.
- For rural areas it can be helpful for farmers in order to examine where the water would flow and look at the area that could be inundated or areas that might need water so that water can be directed .

Objective of project.

To find the amount of rainfall on two Subwatershed within Willamette River and then calculate total runoff based on many steps are done in this project which will be discussed in this report. In addition, two Subwatershed that we focused on are represent both urban area and rural area. Therefore, in result section the comparison will be between two Subwatershed one of them represents rural area while the other represents urban area. As it is known more water streaming in watershed area that are at a high risk of flooding or droughts in streams. In particularly I want to identify two specific Subwatershed within the bigger Willamette river valley basin and focus this research/paper for these two Subwatershed basin within Willamette.

Site Description

- **Willamette Valley.**

Willamette Valley is in the NW part of the state of OR.

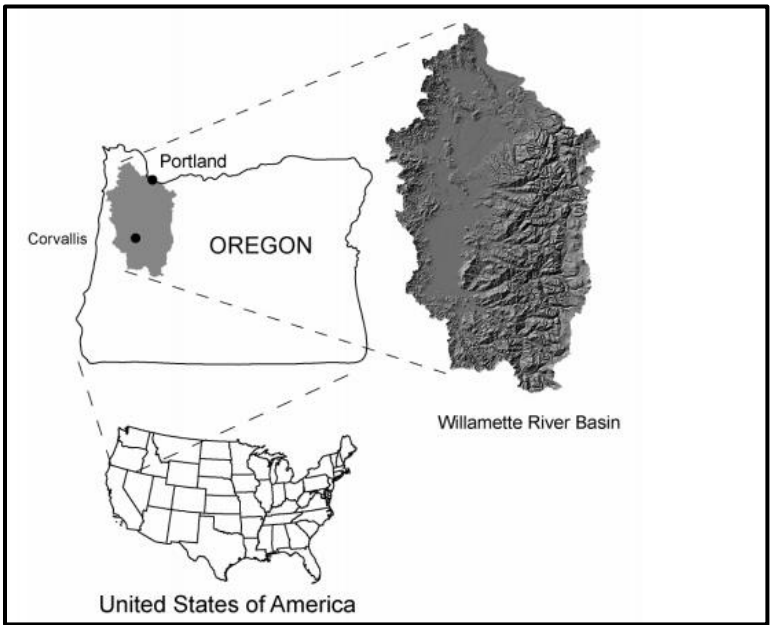

Fig 1: Location of Willamette River , Oregon (Hernandez et al, 2010).

"It's named after the Willamette review that stretches nearly 300 miles from its headwaters at Waldo Lake near Eugene to the confluence with the Columbia River in North Portland. With 11,500 square miles, it is also the largest watershed and the most urbanized watershed in the state" (The City of Portland, Oregon(n.d)).

Willamette river is moderate during the year. This occurs because river gets dry and warm during summertime while in the winter river gets cool and wet (Taylor, 1993).

The climate is more likely to Mediterranean climates which also exist in California. However, the winters in Oregon is more cold and wet (Taylor, 1993).

In the west of Willamette River huge amount of rainfall is received. Basically, Precipitation is related with temperature which is increased with cold weather which is take place between September and April which is the peak of rainfall for our area of interest (Taylor, 1993). During the rainfall season the amount of precipitation is estimated by 70 to 80% (Hernandez et al, 2010).

In watershed like Willamette the quality of water also is very important to be considered within research conducting in this area of interest (Hernandez et al, 2010).

Furthermore, Willamette valley river basin is divided into 3 ecoregions by Coast Range, Cascades Level III Ecoregions as defined and the Willamette Valley Ecoregion (Baker et al, 2004)

Fig 2: ecoregion Area of Willamette River (Baker et al, 2004)

Around 70% of basin area is forest , specifically in upland areas which is in the map Cascade and Coast Range ecoregions. Therefore, these regions became used in agriculture industry by around 43%. Furthermore, around 31% of timber harvest in State has been produced by this area(Baker et al, 2004).

- **Pudding Subwatershed and Keizer Subwatershed.**

- **Pudding Subwatershed**

Pudding Subwatershed is one stream of Willamette reiver valley. Pudding River is running through two Oregon counties which are Clackamas and Marion counties. The location of Pudding is East of Salem city. The area that I studied in Pudding Subwatershed is more rural area which run through area that is more agriculture and forest area (Danielle Strom. (n.d.)). In addition, the area of Pudding Subwatershed is relatively high with 530 squares miles. In the figure 3 it is shown the location of Pudding River that USGS identified.

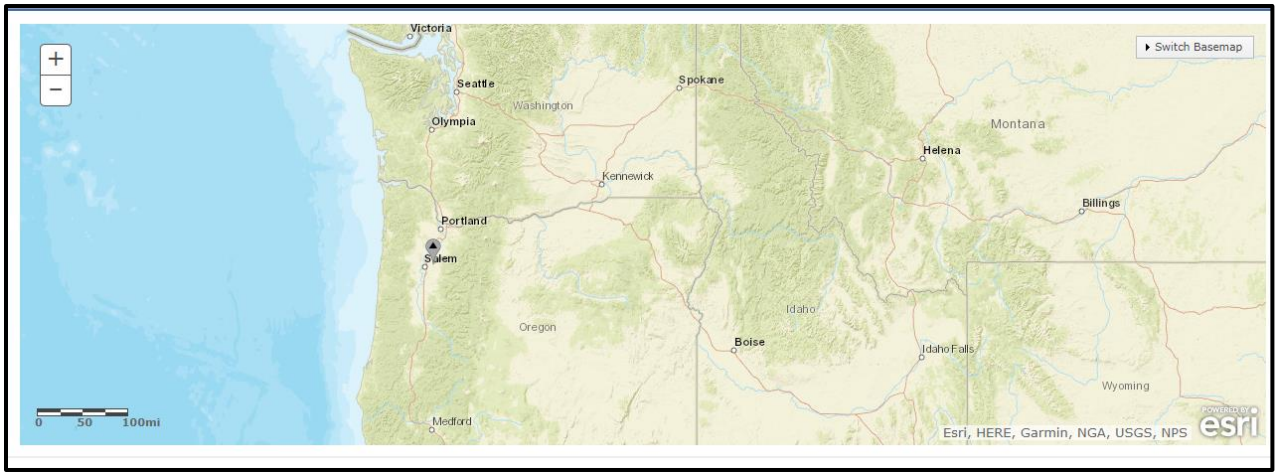

Fig 3: location of Pudding River from USGS database

- **Keizer Subwatershed.**

It is part of Claggett creek which is stream that goes into Willamette River. Even though Keizer Subwatershed is relatively small area but is really important location to focus on since it is near to residential area. The main purpose of focusing in this tiny stream is this stream goes in population area in Keizer city as it is appeared in Figure-4 based on Google map.

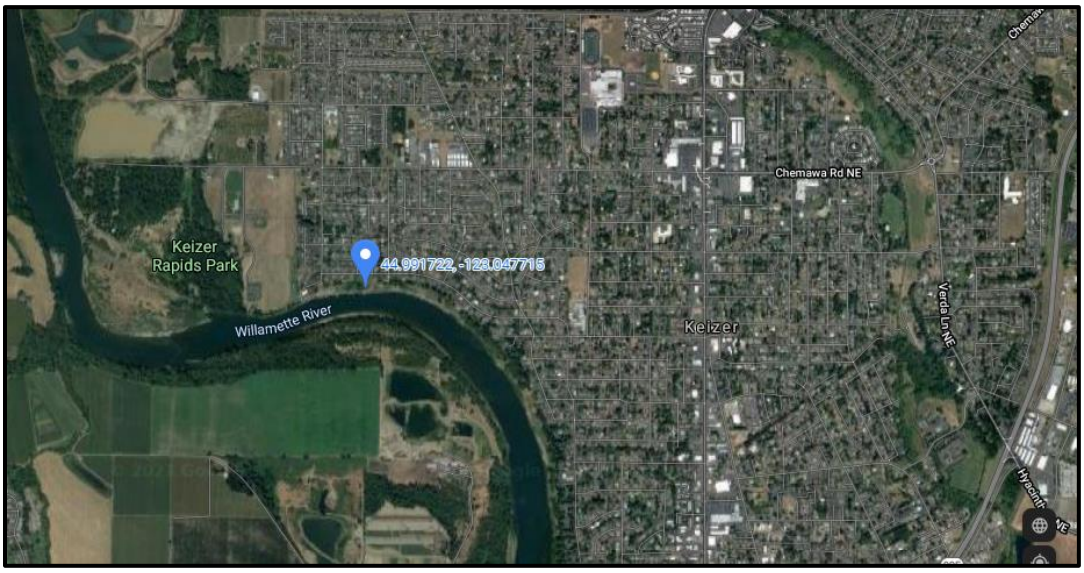

Fig 4: location of Keizer Watershed from Google map that shows population area.

Data I will use for this project.

The data used in this project will be derived from a verity of different sources. A majority of the analysis done in this project will be based on the Oregon 30m Digital Elevation Model (DEM) – raster dataset available from Oregon Spatial Data Library. I will also be downloading precipitation data for the project from Living Atlas Database which is in a raster form. Finally, I will add in information regarding the Land Use land cover for the Willamette valley also from Oregon Spatial Data Library.

Data Provided	Data Source	Type of Data	Resolution
Digital Elevation Model (DEM)	Oregon Spatial Data Library + ArcGIS database	Raster Data	30 m resolution
Land Use Land Cover (LULC) , 2011	Oregon Spatial Data Library	Raster Data	30 m resolution
Precipitation Data To get USA mean Rainfall	Living Atlas	Raster Data	24,000 x 24,000 pixel

Table 1 : Summary of Data Used in This Project.

Methodology

General Methods.

- Use the DEM to create different basins within Willamette Valley river basin using the basin tool.
- Based on the DEM created, select a specific sub river basin within the Willamette Valley river basin and create a watershed using a specific pour point
- Convert the tabular format precipitation data to point data using XY coordinate.
- From the point data use interpolation method to look at the different possible rainfall levels within the area of interest (Raster data format)
- use the available watershed data and the rainfall data to examine the areas that have a high potential for flooding.

Methodology Using in ArcGIS in More Detailed.

- Downloaded the Oregon Watershed Shapefile which had all Oregon watersheds listed.
- Identified two sub-watershed within the Willamette watershed.
- The identification of the two Subwatershed was done. One Keizer sub-watershed contained a more urban land cover. While the other one is Pudding Subwatershed which is located in a more rural area with forest cover and agricultural land cover. Wanted to look at the different Subwaterheds are a more rural area as compared to a watershed in a more urban setting .

After Downloading needed data and Identified area of interest now let us dig more in ArcGIS step in order to perform this project and get the final product. In these methods most steps will be followed with screen shot from real ArcGIS project so it will be more visual and make sense for readers and audience.

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1- Got the DEM

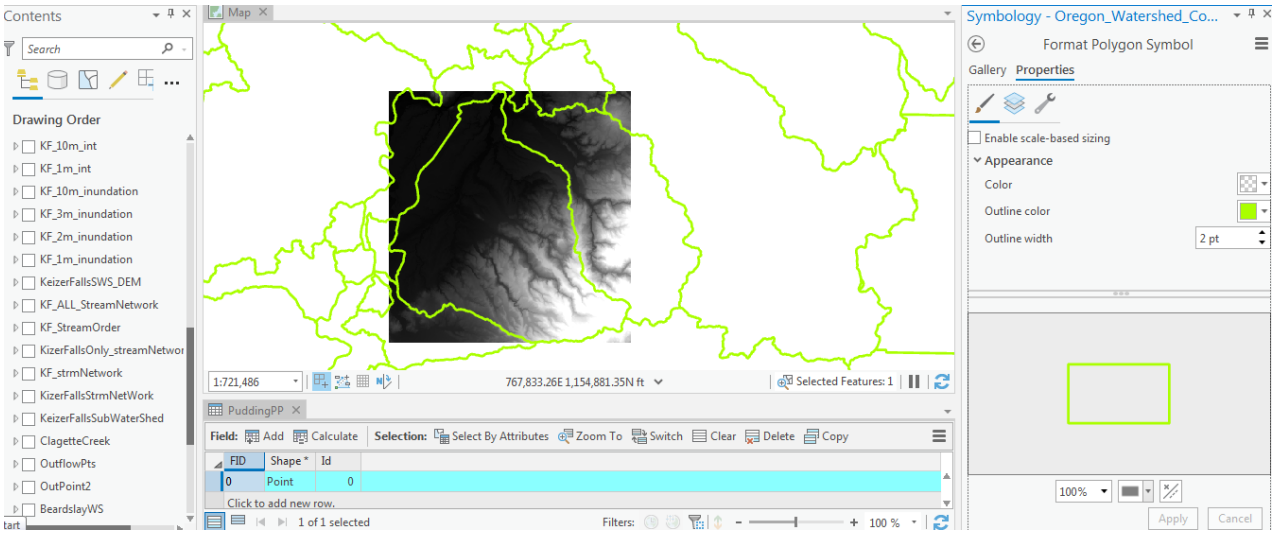

Fig 5: DEM for one of the Sub Watershed within Willamette Watershed

2- Created a Fill (so that there are no sinks within the DEM for the given Subwatersheds).

3- Created the flow direction raster from the Fill. The purpose of this step is to calculate flow direction for grids.

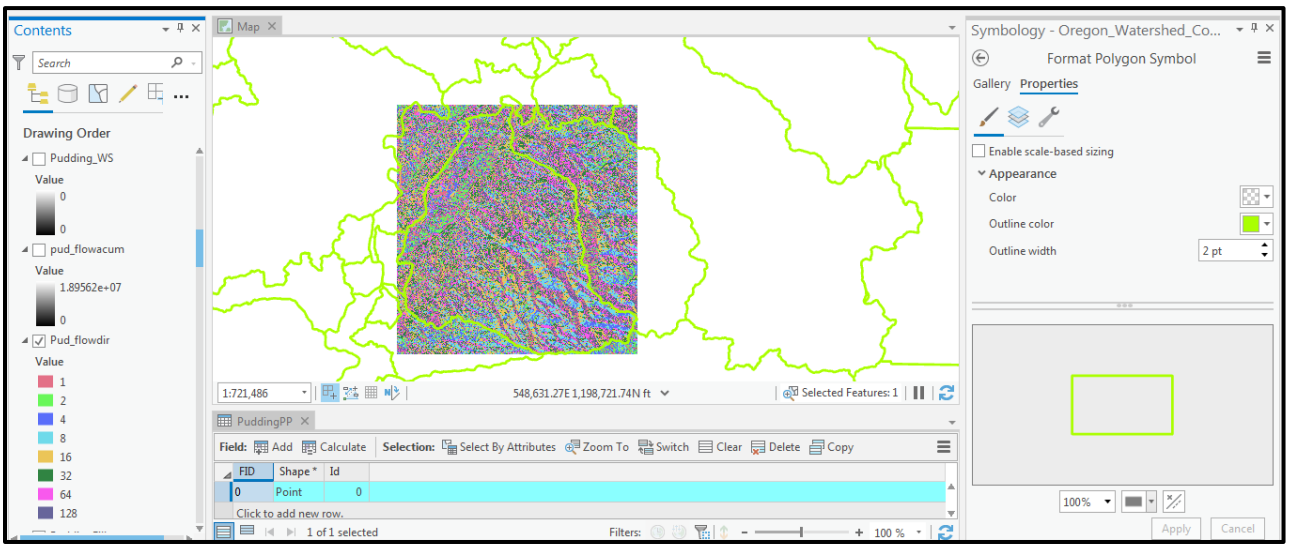

Fig 6: Create Flow Direction for one of the Sub Watershed within Willamette Watershed

4- Created the flow accumulation raster. In this step we are calculating flow accumulation for grids.

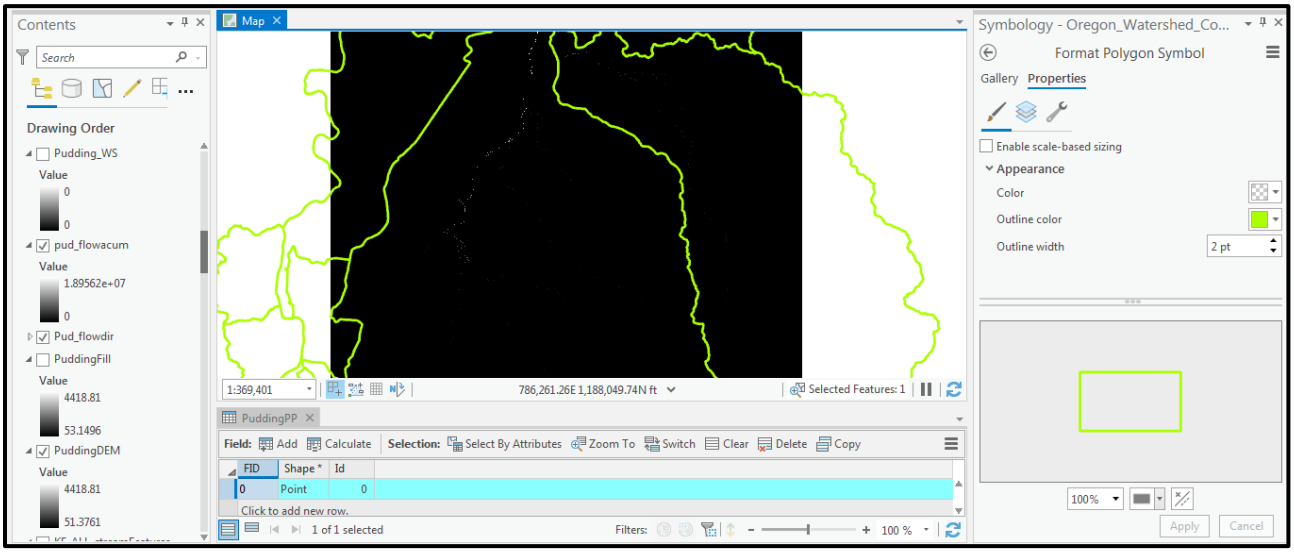

Fig 7: Create Flow Accumulation for one of the Sub Watershed within Willamette Watershed

5- Selected the pour point within one of the watersheds within the Willamette Watershed based on the flow accumulation raster. One for an urban setting and one for a rural setting. It is the point where the river is going to flow out of. It is the pixel with a high flow accumulation value.

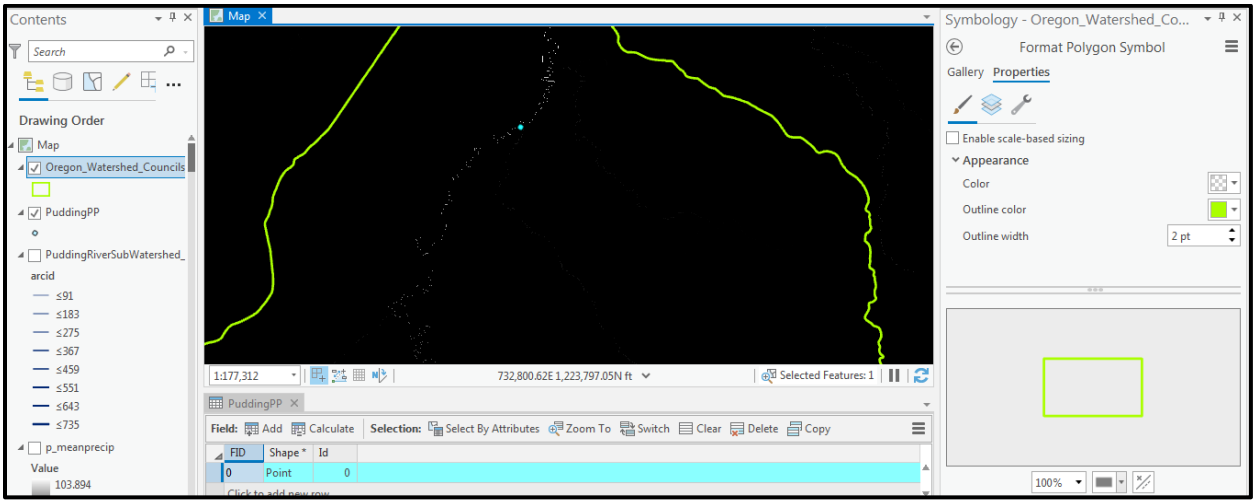

Fig 8: Create Flow Accumulation Selection of Pour Point for Pudding Subwatershed

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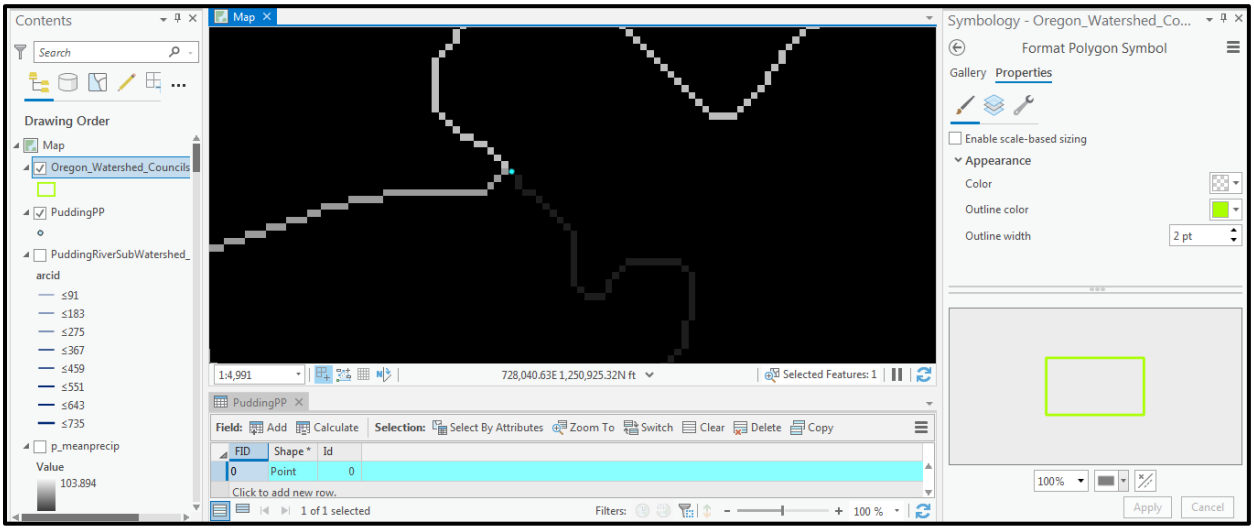


Fig 9: Create Flow Accumulation Selection of Pour Point for Pudding Subwatershed

6- Extracted the watershed for the two settings (one for urban represented by Keizer falls Subwatershed and the second one for a more rural setting represented by Pudding Subwatershed).

7- Extracted the stream order for each of the two Subwatersheds. In the step we assign numeric order to stream link to identify type of streams.

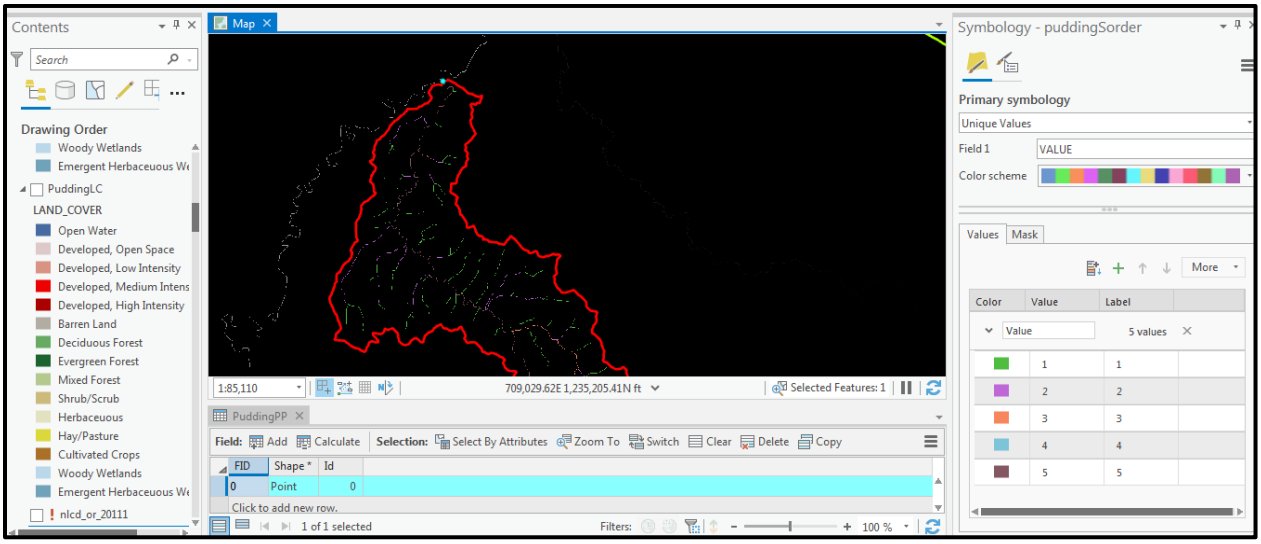


Fig 10: Extracted the stream order for each of the two Subwatersheds.

8- Calculated the area for two Subwatershed.

9- Downloaded the land cover from the National Land Cover Database NLCD.

10- Clipped the Land Cover for the two Subwatersheds.

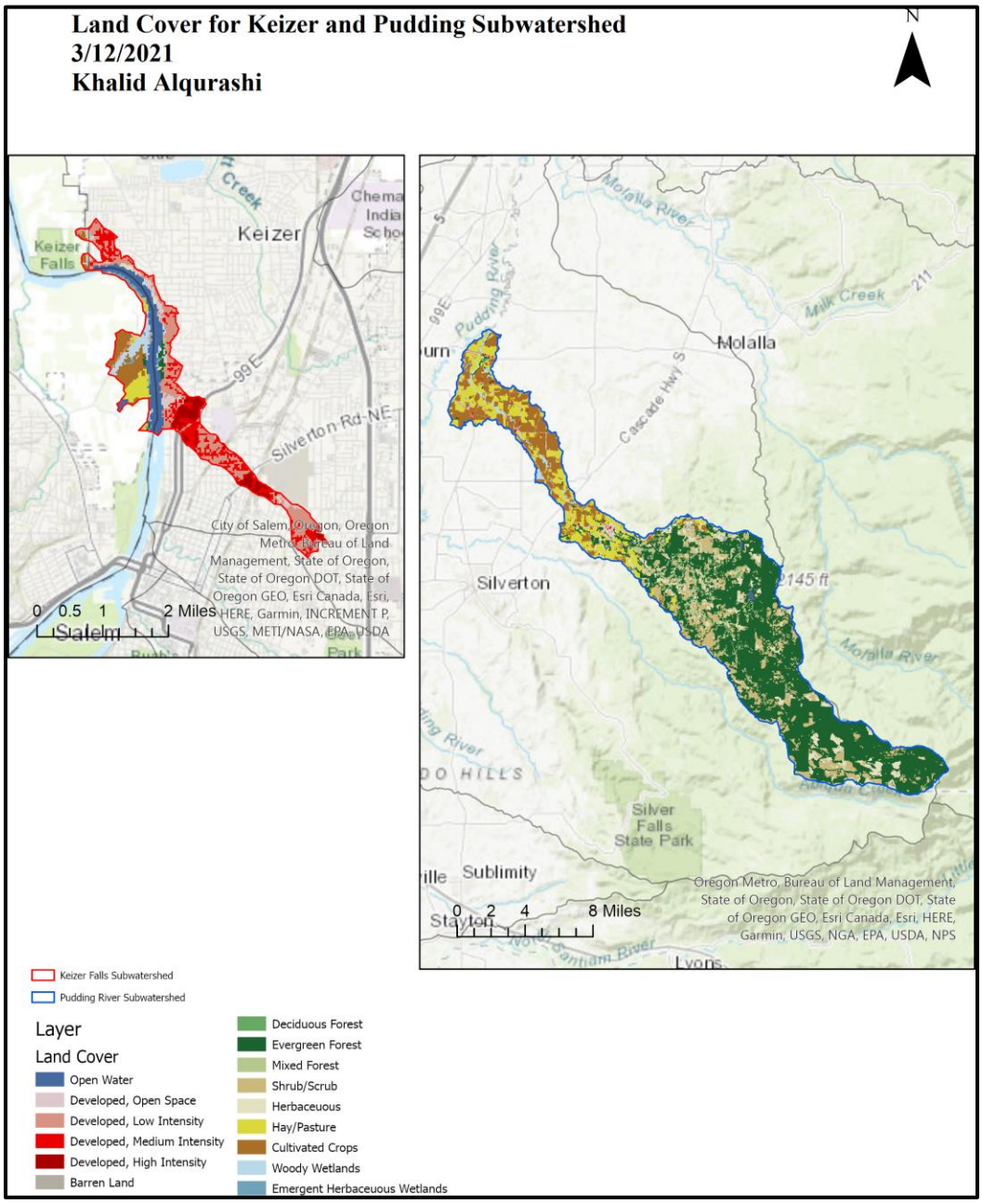


Fig 11: Professional Layout after Clipping the Land Cover for the two Subwatersheds

11- Used reclassify tool to classify each of Land Cover data for its respective Runoff coefficient (Dhakal, 2012). According to Dhakal, N. (2012) the following table shows different runoff coefficient based on surface that water running in. I used these factors to calculate total runoff for area of interest. I just mentioned in this table runoff coefficient for this project.

NLCD classification	NLCD classification description	C (Runoff Coefficient)
21	Developed, Open Space	0.4
41	Deciduous Forest	0.52
42	Evergreen Forest	0.48
43	Mixed Forest	0.48

Table 2 : Runoff Coefficient based on land cover (Dhakal, N. (2012))

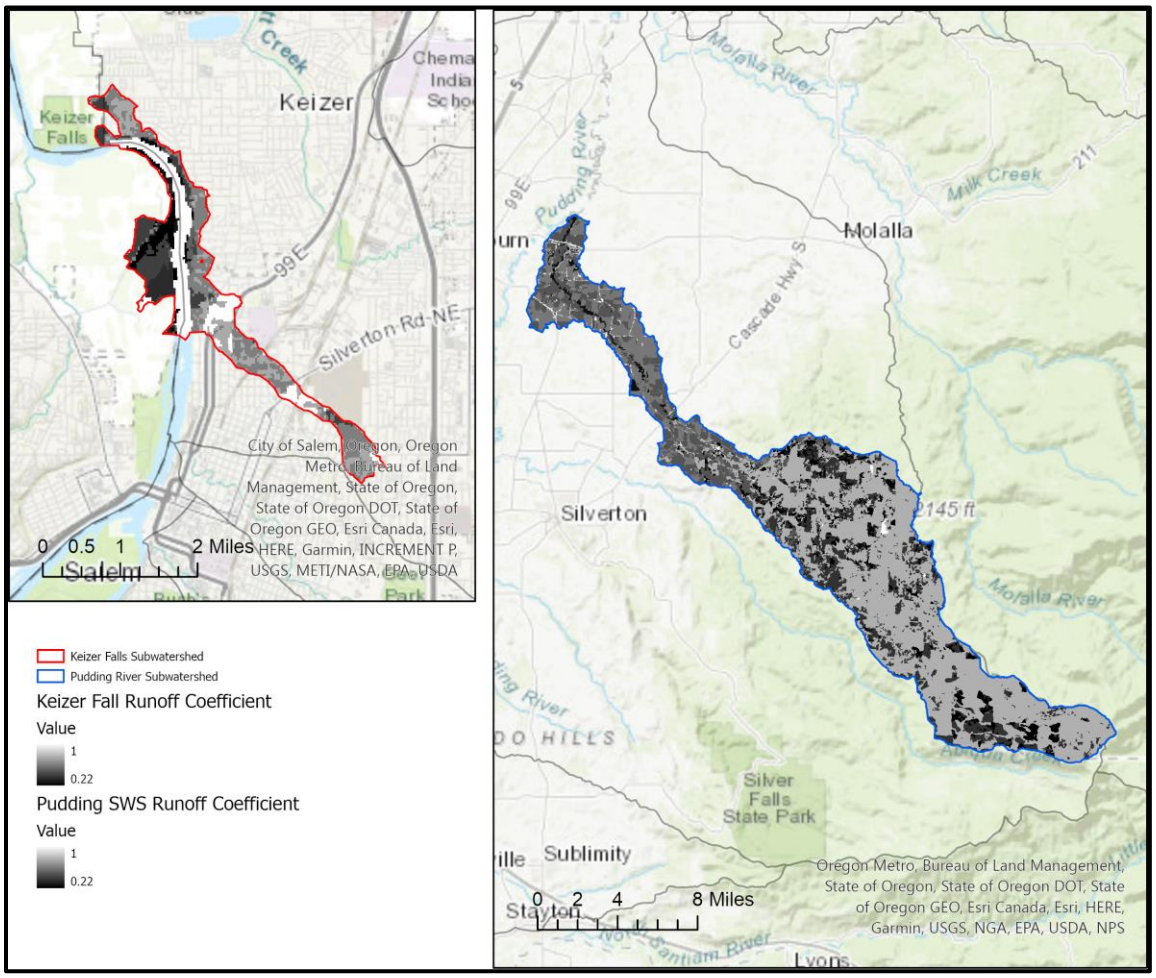


Fig 12: Professional Layout showing distributed of Runoff coefficient based on Land Cover for the two Subwatersheds

12- Downloaded the precipitation data.

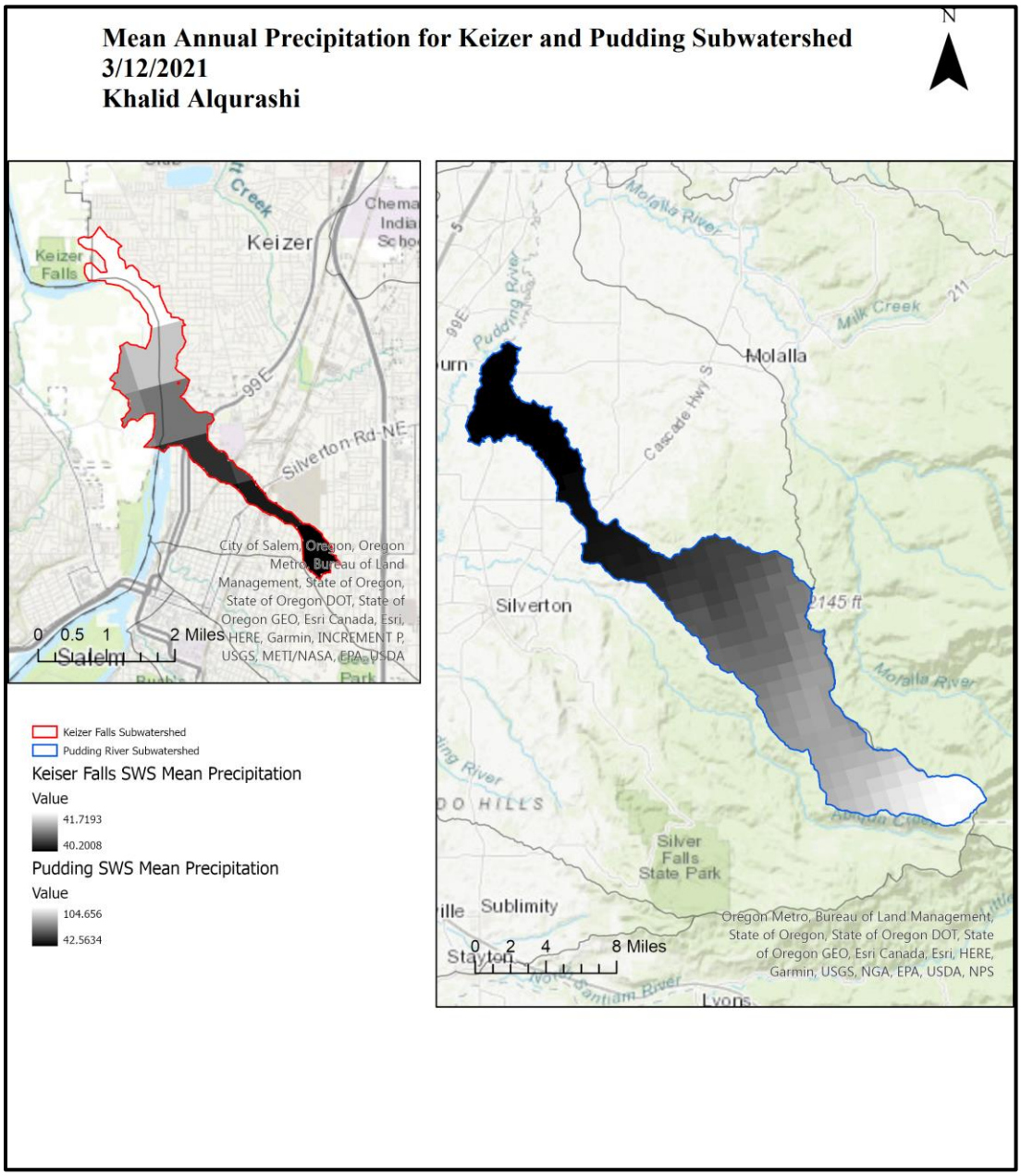


Fig 13: Professional Layout Mean Annual Precipitation for the two Subwatersheds

13- Used Zonal statistics to aggregate the precipitation data for each of the landcover class.

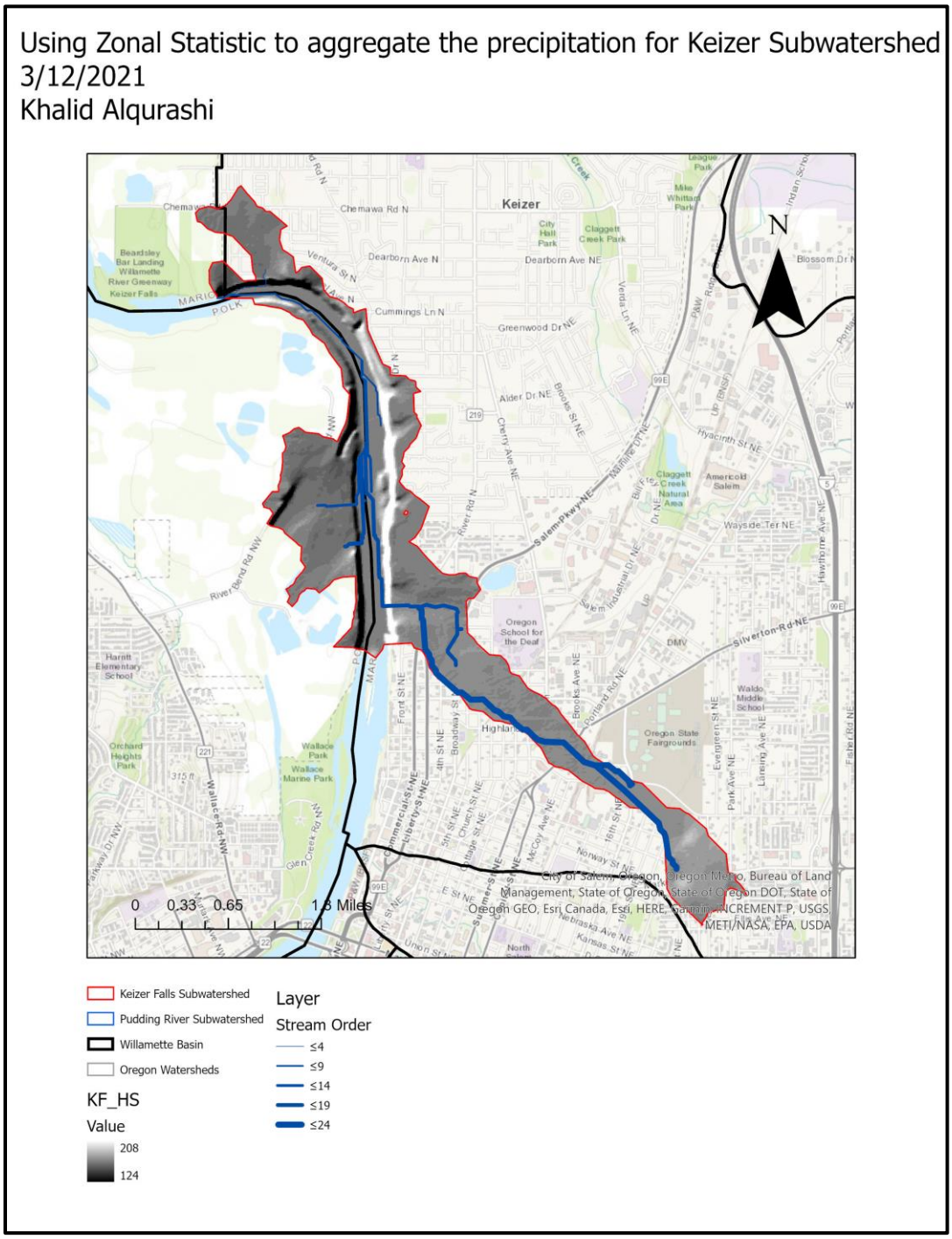
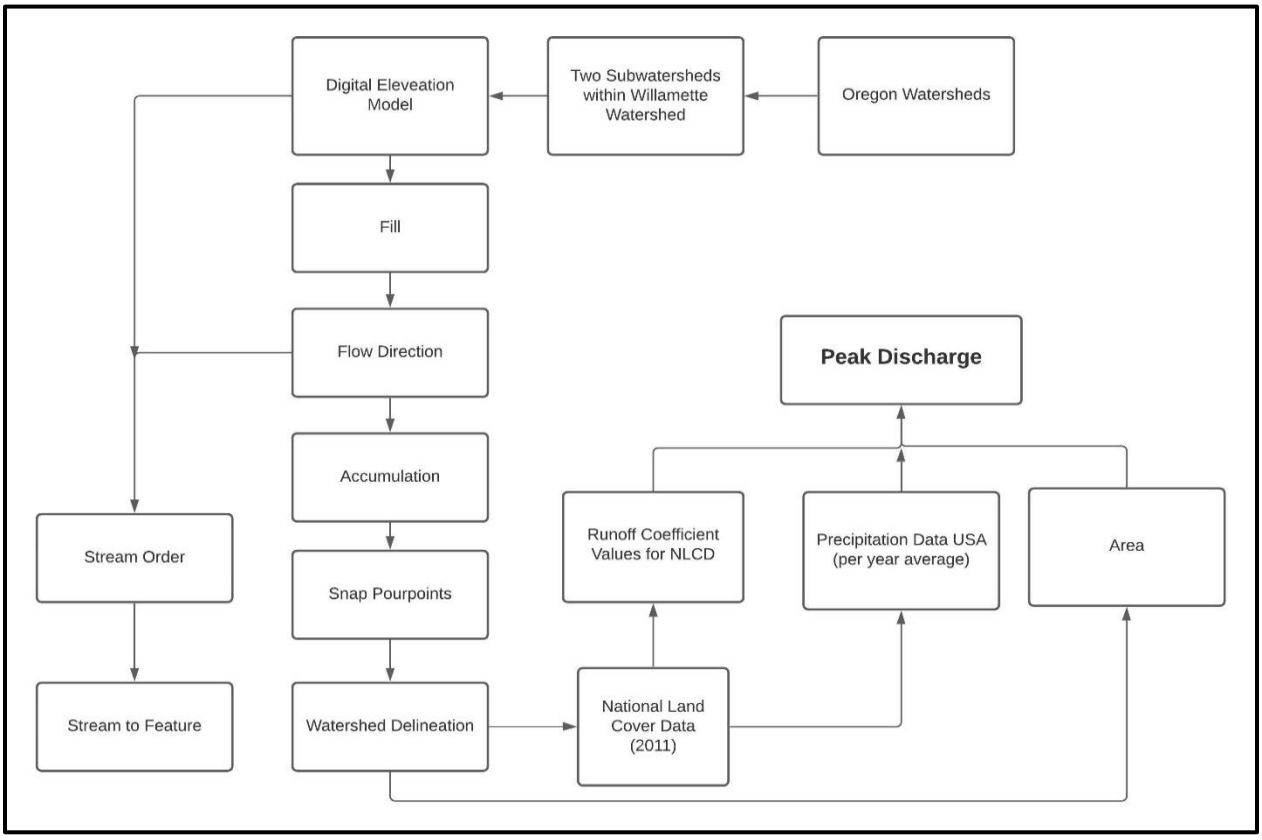


Fig 14: Professional Layout Using Zonal Statistic to aggregate the precipitation data for the two Subwatersheds

14- Using the value for the Area, the Precipitation data and Runoff coefficient calculated the peak discharge for each of the 2 watersheds.

To Summarize the main steps , following flowchart is simplified the process done for this project.

Flow Chart illustrates steps from DEM to get Peak Discharge for two Subwatershed



Outcomes/Results

In the result it is obvious that Discharge in Pudding Subwatershed is relatively high due to higher area for this Subwatershed as compared to the smaller Keizer Subwatershed.

For the Pudding Subwatershed we can see that the stream network contributing to the pour point within the watershed is relatively complex with the highest stream order of around 735. In comparison the stream network for Keizer Falls Subwatershed is less compared with the higher stream order of around of 24. with more than xx number of tributaries flowing into the stream

Site Name	Area (meter Sq)	Cxi (meter per year)	CiA (meter cube per year)	CiA (meter cube per hour)	Q (meter cube per second)
Keizer Subwatershed	3743647.9	2529.37	9469070689	1080944.143	300.26
Pudding Subwatershed	177059728.1	140656.01	2.49045E+13	2842981151	789716.99

Table 3 : Peak Discharge for area of interest Q

Discussion:

Additionally, this research can be helpful to anyone who is looking for data regarding the given Subwatershed. For example, in case of Keizer Falls which is in an urban setting, the Subwatershed delineation and the stream mapping can help city planners to identify areas where flood inundation within the urban areas might occur. Whereas for Pudding Subwatershed, the information derived from this project can be helpful to farmers who have their farms within the Pudding Subwatershed to determine where the stream flows are and how the stream is flowing through the watershed the farm is a part of.

Conclusion:

In this project the main focus is on two Subwatershed within Willemite Watershed as a case study. In this research the main focus was on precipitation which led to identify total runoff for area of interest. To get that done data from various Oregon and United States sources have been downloaded and used as mentioned at the beginning of this report. In addition, the main software used to get the result is ArcGIS Pro. In ArcGIS, many steps and processing were done to get the final product which was calculating total runoff for area of interest. To make the case study fair the two Subwatershed have been focused in are represents two different area categories. Pudding Subwatershed lied on agriculture and forest area while Keizer Subwatershed represents population area. In this way , the concepts are done in this research could be generalized on other surfaces with respect to any different

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