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GIS INTERNSHIP AT TIGHE AND BOND

YUANTING QU

DEGREE WILL BE CONFERRED MAY 2017

A GISDE final project paper

submitted to the faculty of Clark University, Worcester, Massachusetts,

in partial fulfillment of the requirements for the degree of

Masters of Science in Geographic Information Sciences for Development and Environment

in the Department of International Development, Community, and Environment

Accepted on the recommendation of

Dr. Yelena Ogneva-Himmelberger, Project Advisor

Abstract

GIS INTERNSHIP AT TIGHE AND BOND

Yuanting Qu

I started working as GIS Intern at Tighe and Bond Worcester Office on May 11, 2016. I was given a multitude of civil engineering related projects to edit, verify, do analysis and process data. I was able to apply my computer programming skills to help the GIS team develop a useful script tool set that will improve efficiency work. This internship provided me insight into how GIS operate as a part of engineering project on a day-to-day basis. Working background, my responsibilities and what I have learned from this internship is discussed in this report.

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Dedication

To my parents, Qiming Shi and my friends.

Acknowledgements

I would like to thank my professors Yelena Ogneva-Himmelberger and Jie Tian for offering me support and being my mentors. Also, the spatial analysis and computer programming knowledge that I obtained from their classes helped me obtain this internship opportunity.

I would also like to thank my GIS director Nat Norton, GIS analyst Sam Swartwout and GIS technician Austin Canty in our GIS team, who guided me in many types of project and taught me the GIS knowledge from the “Real World”.

At last, I appreciated the time that Sara Brown and Elizabeth Kubacki spent with me on revising and improving this paper.

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CHAPTER 1: INTRODUCTION

“The digital global will let people know everything in the world.” this is the sentence that I have had in my mind from six years ago, which lead me to the greatness of GIS. Following that, I majored in Geographic Information System at Northeast Forestry University in China. My GIS journey started six years ago with a focus on forestry and remoting sensing but switched to vector analysis and programming after choosing Clark University’s Geographic Information Science for Development & Environment program. Clark’s program has offered me very attractive courses regarding practical skills and good research environment that has a huge impact of shaping my career goal.

To apply these skills I chose the internship track for the sake of better preparation for future job. I got a valuable internship offer from Tighe and Bond, an engineering and environmental consulting company that fits my interests about urban development, vector analysis and coding. My internship started in early May toward to the end of August 2016 as the summer stage. I was working at the Worcester office as a full time GIS intern, one member of GIS team, during the summer. This internship continued as part time GIS intern throughout this academic year.

I am lucky that I was embraced by this group of people from Tighe and Bond and I am glad to have the responsibility of GIS member as well as a role of accomplishing GIS On-call support task, incorporating engineer working on GIS request and interacting with other professional team members to provide help or seek suggestions from each other. This internship experience has brought me to a different level of acknowledgement of what is GIS, what kinds of problem that GIS can solve, how can it helps people and how to do GIS work in most efficient

way. All of these benefit me from a different angle about GIS compared with what I have obtained from the classes and final projects as it would generate a long term impact to my future.

This GIS internship are considered be the perfect first step of my career plan.

CHAPTER 2: DESCRIPTION OF ORGANIZATION

The company, Tighe and Bond, is a regional pioneer in the engineering and environmental field as consulting company, which provide solutions for diverse projects that related to permitting, planning and design. GIS is one of the tools they use to execute solutions or develop contracture of projects.

2.1 Mission and Expertise:

“Tighe and Bond began as a broad-based civil engineering firm specializing in water resources, bridges, and roadways, has continued to evolve in response to the changing needs of clients in a changing environment. Our now also specialize in various aspects of environmental engineering — such as water, wastewater, solid waste and storm water management. Our experience ranges from consulting on limited projects for small businesses to designing two of the largest wastewater residuals drying facilities in the world.” (Tighe & Bond, 2016).

“Our portfolio of expertise also includes environmental consulting for brownfields, hazardous materials, wetland and ecological services, permitting, planning and more. In addition, we provide an array of building, geographic information systems, and sustainability services for a wide range of clients.” (Tighe & Bond, 2016).

2.2 Organizational Structure and GIS Expertise:

Tighe and Bond was started over 100 years ago and have more than 300 employees. Headquartered in Westfield, Massachusetts, the company has seven other offices located at Middletown, Connecticut; Shelton, Connecticut; Pocasset, Massachusetts; Worcester,

Massachusetts; Portsmouth, New Hampshire; Westwood, Massachusetts; and Red Hook, New York.

The Worcester office is where I spent my summer interning. Tighe and Bond's departments including IT department, contract group, marketing department, finance department, human resources department, technical resources and service department that made up by a group of engineers and environmental scientists that running three business line including energy and environmental, water and site civil & transportation. As an organization, the whole company will have served and established contracts with numerous clients from different sectors such as state & local Government, Water Utilities, Power Unities and so on.

GIS work and mapping were performed primarily in the GIS department as part of technical resource. The GIS department is made up of ten GIS professionals including one GIS Director, three GIS analysts, four GIS technicians, one web developer, and one GIS intern. This group of GIS people are working in three locations (Westfield, Worcester, and Middletown CT), which provides a full range of GIS services. Some GIS work and mapping were also performed by non-GIS staff like engineers, environmental scientists, and technicians. Field data collection is performed by environmental scientists using GIS software on iPads that will transfer and modify the data to geodatabase.

Every person on the GIS team has experience working with diverse projects aiming at different areas and related to different type of work such as project management, online data management, fieldwork, data cleaning, data and attributes digitizing, modeling and analyzing, map creation, customize scripting and programming, database building and managing, GIS implementation planning, GIS software training and so on, contributing to the solution and

maintenance for cities underground pipe service system and many other sides of civil engineering development as an effective team in Tighe and Bond company.

As one member of the GIS team, our team develop cutting-edge custom GIS applications for both public and private clients based on their requirement and purpose. In addition, our team is an ESRI business partner that provides a close working relationship with one of the most popular GIS software vendors. Our staff includes an ESRI authorized training instructor as well as a certified GIS professional (GISP). (ESRI, 2016)

With a full range of ESRI products, it helps us improve work performance and efficiency. Besides the use traditional geodatabase distributed though out the different servers (share folders) for storing and sharing the GIS data, we also embedded SDE server geodatabase for multiple synchronously data editing and enterprise level data managing. ERSI collector and ArcGIS Survey 123 are constantly used for fieldwork like data collection and data correction, which will update the data to the online map and geodatabase. Comparing with ESRI collector, Survey 123 perform smarter and more efficient during fieldwork. The existing template of geodatabase and map layout will be used for populating data and map creation. Each features inside different layers will be filled with detailed attributes according to “as built plan” and field work, plan extent layer with attachments of plans will be created for using to verify the parameters in the plan when people at the real location. For data analyzing and modeling, several developed models and script tools will be used by engineers to obtain final results or solutions to different projects. Some small assistant tools will be developed by using python and other language. Many websites conveying our final map products will be built and published by using HTML, CSS and JavaScript. Together, it formed a good partnership of other departments and strengthened the whole organization.

CHAPTER 3: INTERNSHIP RESPONSIBILITIES

My GIS internship at Tighe & Bond started with the training and cooperating with three other GIS team members including a GIS team director, a GIS analyst, and a GIS technician in the Worcester office. Most projects were delivered by the GIS director through the group meetings or emails. The majority of these projects are related to sewer, water or storm water, which focus on data processing, feature and attribute editing, map creating, analyzing programming and series of GIS related works.

3.1 Utility Project Data Editing and Management

As a GIS team member of Tighe & Bond, it is common working on multiple projects at the same time. The project on sewer system capacity analysis of Stratford, CT is the most representative long-term project that I have been involved in, as well as a good example of how GIS fits or functions into an engineering project. Before the Tighe & Bond got the bid of this project, the town of Stratford was concerned about the town's sewer system capacity in term of the amount of water running to the treatment plant. The treatment plant is a facility associated with each town that will process the wastewater running out of the sewer system by filtering, using chemical treatment to bring wastewater back to clean and eventually release clean water to natural environment. However, the treatment can only deal with certain amount of water per day; it has to discharge the wastewater to environment if the input water exceeds the treatment plant's limitation. To prevent the environment pollution, the city must monitor the capacity of the sewer system to minimize the amount of water in it. As the age of the pipes get older, the change of the circumstances, such as the tree's roots grown in, will cause the pipes to have many cracks on the surface, which will further induce extra water into the sewer system. There are two types of

water, which will cause sewage volumes to exceed the design capacity. One water type is called Infiltration, which refer to the groundwater entering sanitary sewers system through the pipe joints and cracks and the other one is called Inflow, which refer to the run off storm water (rainwater) that was not caught by storm water system but entered into the sanitary sewers system. Tighe & Bond’s main goal of this project is to figure out what kind of water is causing the dilution in sewers and reassess the capacity of the whole sewer system. To monitor the amount of water running in different part of sewer system, setting meters for certain manholes were consider to be the first necessary step. By doing this, the engineering team could record the volumes of water to compare with these sections design capacity. Then, they analyzed and assessed the water volume variation and ground water elevation changing as the Figure 1 shows below.

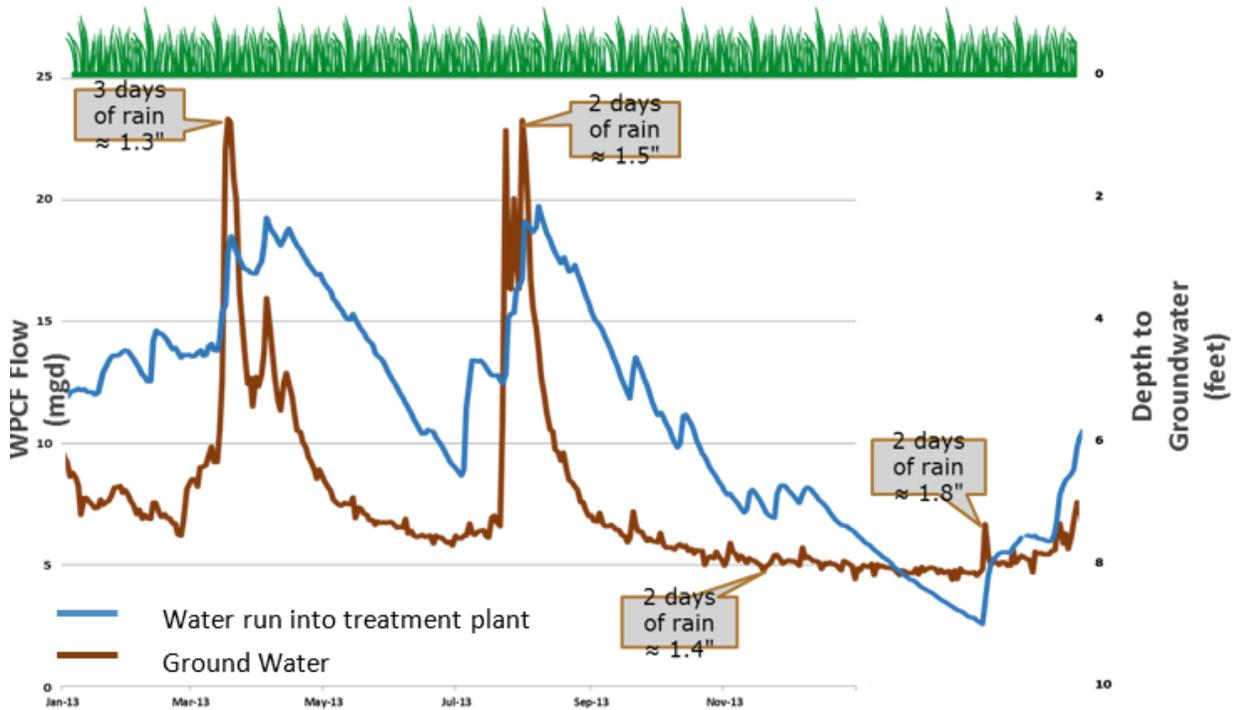


Figure 1: Chart of ground water and treatment plant water changing

The blue line represents the changing of total water flow that went to treatment plants, the brown line means the changing of the ground water elevation. The two lines in Figure 1 show peaks at same time. And all the small increases and decreases for both water types shows the water volume variation caused by precipitation. Based on these results the engineering team could conclude that the groundwater is main source that will affect the volume of water in sewer system and the Inflow water will only cause small variations in the sewer system.

In order to detect which section of the pipes will be affected by Infiltration, a comprehensive GIS database of the whole towns' sewer system needs to be developed. That is the part where GIS will contribute as important role as preparation stage to further modeling. The whole GIS database has been established through SDE which is an enterprise geodatabase that allows more than one person editing at the same time. I was involved in populating attributes for sewer features, manholes, and pipes according to the engendering As-Built plan as the right side of Figure 2 below. The attributes need to be extracted it from As-Built such manhole's surface elevation, manhole's invert value, pipe's slope, pipe's Up-stream invert value, pipe's down-stream invert value, pipe's diameter, pipe's material, Plan's year and so on. Meanwhile, a spreadsheet for recoding the process of 1400 plans was created at the beginning of GIS stage of this project. Another task is digitizing plan extents that include pipes greater than 10 inches and sewer watersheds. The map of these data shows like middle part of Figure 2, the left part of Figure 2 is the working environment shown from ArcMap.

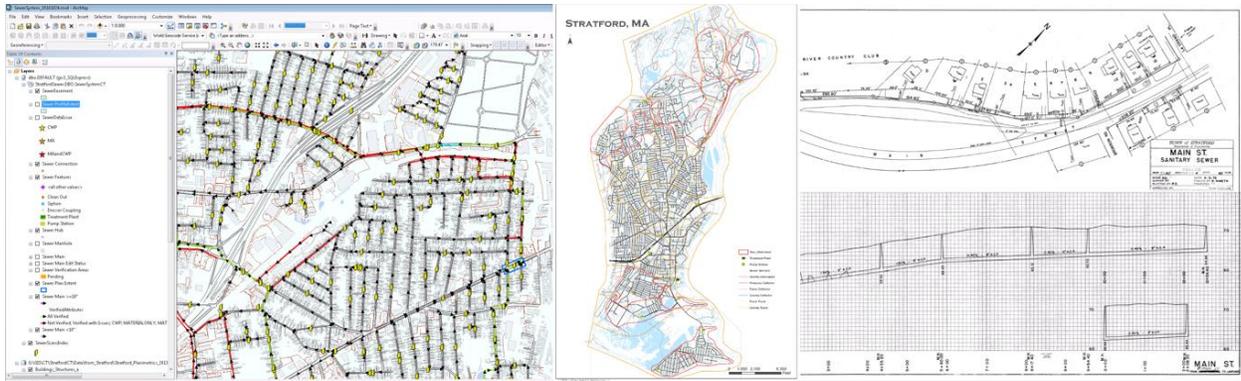


Figure 2: Stratford project's GIS developing environment

As the data developing stage completed, this project was taken into analysis stage. The GIS team incorporated with engineer team together to analyze and model this project as next stage which we have been working on till recently. The main goal of this stage is to figure out which section of pipes that distributed in the town are affected or always saturated in the ground water that keep causing dilution in sanitary sewers system, as well as robot inspection, analyzes diurnal flows, negatively sloped pipes, surcharged pipes, capacity of the pipe. Eventually, they will have people to dig out and replace the problematic pipes to reduce the volume of water flow into treatment plant in order to achieve the final goal of the project.

Another useful work is to develop plan extent for engineering As-Built plans. For instance, I have completed a Plan Extent development for Trumbull, CT. Basically, drawing the geographically outside boundary according to pipe design plan extent, populating related attributes and then attached the plan itself as a PDF version is the main way has been done.

Therefore, after these data have been put on ArcGIS online, the user could view these data from ArcGIS collector on their cell phone when they are in the field. As the Figure 3 shows below, the real plan could be pull out from feature's attachment depending on the user's geographic

position. Which could be very helpful and useful, even for type of the client who want to evaluate these data in the office.

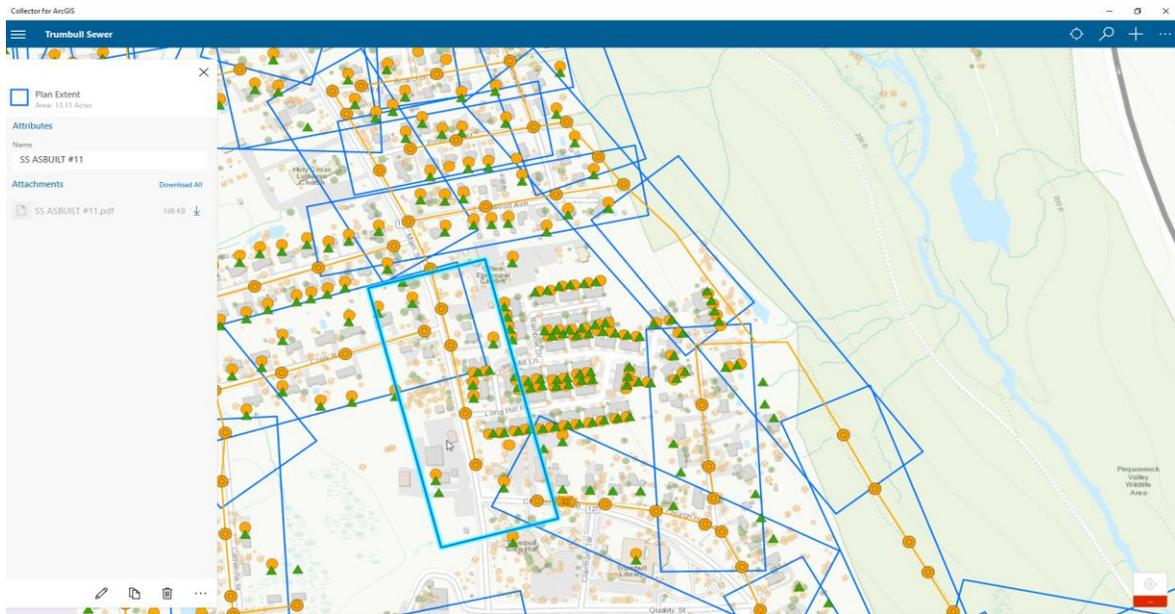


Figure 3: User Trumbull project's data view from ArcGIS Collector

Other projects were also conducted during the internship and are listed below:

- Dalton MA, Shadly and Salisbury CT Sewer System GIS Support and Analysis: Digitizing manhole points, issue points, sewer mains, attributing sewer mains and recoding the data issues, drawing all plan extent.
- Avon, CT-GIS On-Call Support and Engineering Services: Drawing plans' extent and adding plan attachment for sewer system.
- Mattapoisett, MA Pond Force Main GIS Support: Digitizing pavement, drive way and side walk.
- North Andover, MA Storm Water Program GIS Support: Digitizing and attributing features from storm water plans. Recording plans' issues. Drawing plan extents.

- Trinity CT Water, Sewer & SW Modeling: Building Feature Editing and catchment editing for town.
- Converting XYZ file Lidar file to feature class and building a terrain dataset.
- LEGO campus, Enfield, CT GIS On-call: Geo-Referencing and Correcting soil boring points.
- Creating and cleaning attachments for Watertown water service area.
- Creating maps and editing features responding to engineer requests.
- Conducting X-ray Add-in tools of ARCGIS to get and compare information from Map document.

3.2 Script Tool and Programming

For another kind of work, I use programming to create some script tools that are able to process some data automatically, developing and running script to compare and check geodatabase, creating script toolbox to automate the workflow.

The Figure 4 shows all the script tools that I developed this past summer. These scripts have multiple functionalities, such as cleaning data, processing files, creating plans' spreadsheet, extracting specific information and automatizing work flow in ArcGIS, which will be easy being operated through windows system desktop, Python Graphic User Interface or ArcGIS toolbox User Interface. List of tools' compatibility of data are designed not only for one specific type of data. The core algorithms of these tools could also be used in other projects by integrating customized designs. To follow up this type of work, I will highlight some programming projects that are relatively interesting and useful.

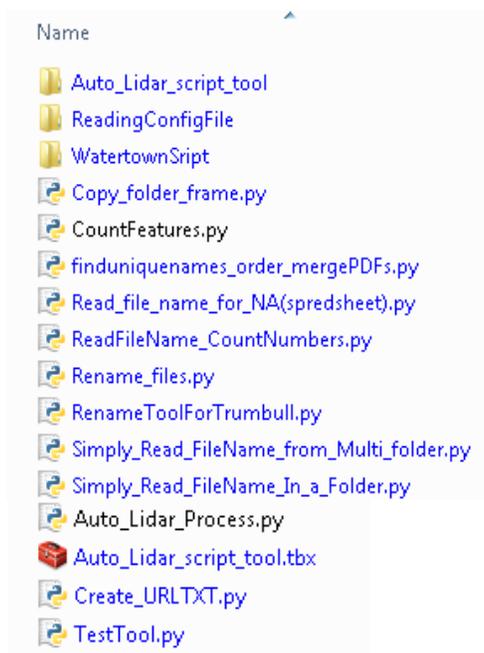


Figure 4: Screen shoot of self-developed small code library (script tool set)

Programming for merging water service cards following customized order is the project that I developed at starting stage of the summer internship. This tool aims at processing and merging water service cards for Watertown, CT water project. One step in this project is try to attach the water service card, PDF format files, to its corresponding address points which are centroid point of parcel, which will enable the clients to view cards geographically. There are about 2000 water service cards for different address points.

When the clients from city hall scanning these two-side water service card's front and back stored separately into two PDF with name that specified the card's address associated with "F" indicates the front of the card or "B" indicates back of the card. However, for some address have more than one service card PDF, so it likely has a lots PDF file named differently that end with F2, F2, B2, F3, B3..... indicating front of second card, back of second card, front of third card, back of third card and by such analogy. What I was trying to create a python script will

automatically merge these files to be one PDF file if the original files are belong to one address location, rename the final PDF file to be just address name and also merge them follow the customized order as I mentioned early, as shown in Figure 5 below.



Figure 5: The way to merge the PDFs for Watertown Project

A python script file was initiated to do this, and I used OS and SYS package for python to access the all the PDF files in windows system, which will also enable the script to access the name of each PDF, rename the PDF. PyPDF2 was used as key package for manipulating PDF files, which will create new PDF that contain all the PDF file have the address same name by attach original single PDF to merged PDF allowing specified order. To develop the customized order to attach the PDF files, I programmed one sorting algorithm by define a function in the python script to sorted all the pages to fit the order to be that project required. After testing the script a few times, the script ends up working out fairly good. It spends only few seconds on merging 2000 PDF files, meanwhile, and creates a table that records which files were merged into which file in order to keep things on track.

Another useful and representative project that I developed is reading information from configuration files and creating a nice format output table of the extracted information. Our company holds a lots of web-mapping websites for our clients. Recently, the GIS team is

updating the website format for sharing the data from Servlet based to JavaScript based. To do this our team need to extract information from configuration file of the old website which stored the content of old website. The configuration was written by mark-up language, which consists of a set of tags and their values. My goal is to develop a tool that will identify these tags that are indicating what kind of value it stores and extract the value to be a nice format text file. The Xml.etree.ElementTree built-in package for python was used to read mark-up language and extract the information that stored in different tags; the string package in python were used to format the output table and the sys package was used to access the configuration in system. Besides these, in order to make this to be more convenient for other team members to use, I also incorporated GUI (Tkinter) package for python to create one user interface as Figure 6 shows below. Therefore, user could just drag the configuration file in and hit create button, the output table will generate automatically in the same of the input file.

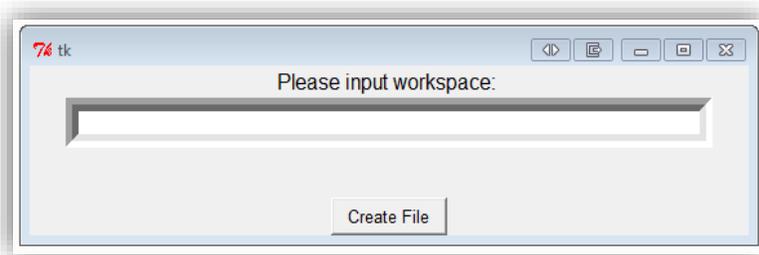


Figure 6: Python GUI (user interface) for input configuration files

Developing script tool in ArcGIS is also a meaningful project that I did during this internship. The script tool is a useful tool to use to help the whole GIS team members to realize automatic workflow and to save some time for doing repetitive process. One script tool I created by using Arcpy package is Lidar to contour tool which combine the Mosaic, the Focal statistic and contour tools together, meanwhile, realized some customized settings for parameters and

processing. The user interface of this tool is displayed in Figure 7 below. By specifying a workspace, all the middle processing outputs will be generated. Multiple raw LIDAR tiles are allowed to put in this tool, the output of this tool will be a contour polyline feature class with preferred coordinates system, desired smooth level, unit according to the values that user put in “choose coordinate system”, “Focal statistic neighborhood settings (height)”, “Focal statistic neighborhood settings (width)”, “Pixel type” and “Z factor” boxes. The Arcpy is a major package for programming this tool; meanwhile, OS and SYS package were also used to access the files in windows system.

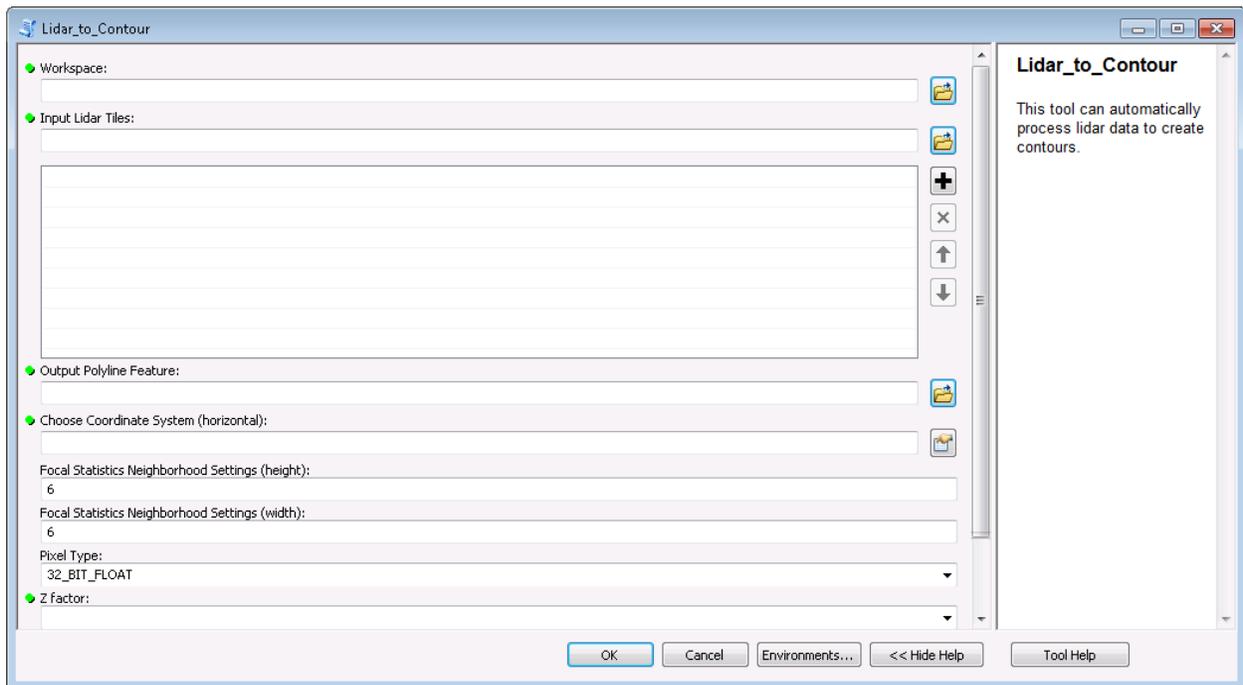


Figure 7: User Interface of Lidar to Contour script tool

Besides that, in “Auto Lidar to contour toolbox”, there is another tool called “Create URL table” like the Figure 8 shows below, that will multiple LIDAR tiles downloading URL in LIDAR index layer. All of these URLs will in a nice format table. Later on, the resulting table can be used in a software named Winget that will use this table to download all the files at once.

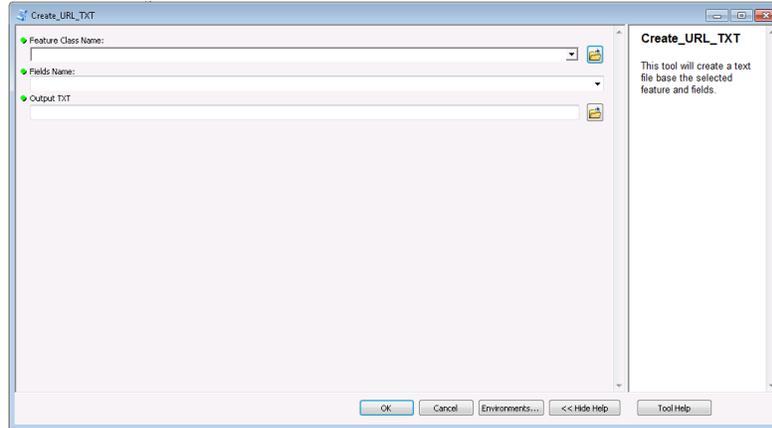


Figure 8: User Interface of URL to TXT script tool

To meet all other diverse project's needs, I also made some small programs to respond to different demands like creating underground pipe system plans' spreadsheet, automatically renaming files, comparing number of features classes and number of features in feature class in two geodatabases, recreating same folder structure and so on. All of these scripting tools, I tried to make them as easy as possible for other people to use, keep updating some of tools to fit different needs and then introduced these tools' usage to my co-workers through meeting or phone.

CHAPTER 4: INTERNSHIP ASSESSMENT

In past one year, two academic semesters and summer internship became a precious and rich experience in my life.

The pervious study at Clark has offered me a chance to become familiar with the American culture and academic environment. Especially, I built up a good career goal through the professional seminar that helped me to evaluate myself by introducing me to the entire GIS job market and helping me find and establish my interests. What's more important are professional and skills GIS courses that I have learned before this internship which benefit me a lot and help me grasp the chance of winning this internship opportunity. For instance, the Intro to GIS, remote sensing, Advanced Raster GIS and GIS for International Development have given me strong fundamental knowledge in analyzing vector data using ArcMap, manipulating GIS data, finding diverse data, theories of remote sensing and advanced image processing & analyzing skills. The skills and techniques that I gained from the python programming and Computer Programming for GIS course were the most useful skills because I was able to create automatic workflows which significantly increased efficiency. I was also able to build an online portfolio after finishing the cartography class. The ability to accomplish a whole project, capacity of solving problem and team working with other people also considered be to the most valuable skills that I learned at school.

Overall from my summer internship, I have obtained hard and soft skills, which is a huge benefit for my current academic study and future career development. I have gained sufficient training from my co-workers at the beginning of this internship. As I stepped into real GIS world, it assisted me to reinforce my GIS skills, meanwhile offered me a new GIS working circumstance

that filled with GIS demand from Client, GIS techniques responding the modern development and the ways to using professional GIS knowledge to incorporate with people from professional GIS team and different fields. I obtained many useful skills from this internship that I would like to highlight some of them below.

- First time dealing with utilities data (sewer, water, storm water system features), even though we have already experienced some vector data. However, the utilities data structure feels like more complicated such as pipe line features will have direction, many unfamiliar water system feature associated with many attributes from engineering As-built plan. It let me know better about what the data look like from the real project and particular data will be needed for particular field.
- Even though I made many maps for pervious projects while using personal color and schema. However, for making engineering project maps I need to follow the template to fit requirements of special elements and formats. Also, I have many new tricks for making map like using data driven pages, using dynamic text, making annotations for engineering figures and so on.
- Doing works from this internship has significantly improved my familiarity and fluency working with ArcMap, Arc Catalog and ArcGIS online. It got me exposed to SDE(popular enterprise level geodatabase), ArcGIS collector and Survey 123(two software for display data on mobile and collection field data).
- Getting to know the interesting projects' background, and knowing what problem GIS could solve, what tool I should use in terms of better understanding the role of GIS in each situation.

- Get to know what kind of projects are needed in the market, how these projects operate and earn profits, how to maintain a long-term project and what kind of final products need to be made to fit the clients need.
- The use of python programming to solve many problems as contribution of project and improvement of working efficiency. To achieve the goals, I taught myself by using the material from internet about how to install and use couple new python packages and then developed a small code library that can be reused on many types of projects, which helped team members' and my daily work a lot.

If GIS students are interested in vector analysis and urban and utilities development, I would strongly recommend this internship to them. Because this internship will offer real, diverse and dynamic civil engineering related GIS working environment; chance to build up professional network from the GIS team or client; help them redefine their interests as well as learn cutting edge geographic information science resources and technologies and encourage them to take related courses before they start seeking this kind of internship.

CHAPTER 5: CONCLUSION

The experience of Tighe and Bond GIS internship shaped me into more professional and skillful person to the GIS discipline. I appreciated the training, helping, teaching and suggestions they have offered to me. I am honored to have had the opportunity to expose myself to diverse GIS projects under the real consulting company to grasp experience with new hard and soft skills and to apply the extensive knowledge obtained from previous study on solving engineering questions. I am proud of the products that I created because they could be used by many people from different towns. The piece of code that I developed could be helpful to my co-workers and the professional network that I have built during this period. This internship not only polished my working ability and professional skills, but also helped me to be more confident to handle engineering GIS cases and to pursue my future career goal.

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