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# Environmental Justice/Urban Initiative Project: Summer Internship with Massachusetts Department of Environmental Protection

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# Environmental Justice/Urban Initiative Project:

# Summer Internship with Massachusetts

# Department of Environmental Protection

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Dr. Yelena Ogneva-Himmelberger, Project Advisor

# ABSTRACT

Environmental Justice/Urban Initiative Project: Summer Internship with Massachusetts

Department of Environmental Protection

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This report serves as a detailed description of my internship at the Massachusetts

Department of Environmental Protection (MassDEP) in Worcester, MA, during the

summer of 2016. The internship was proposed by Brian Postale, the Urban Compliance

Initiative Project Coordinator as a way to automate the integration of GIS data and the

computation of data used for visualization purposes. The purpose of this paper is to

describe the structure of the organization, my responsibilities as an intern, and my

assessment of the internship.

The internship proved to be a precious experience and provided the opportunity to

apply and enhance my knowledge and skills learned in Clark University to the work place.

I gained more understanding of the working dynamics while practicing skills, meeting with

people, and being exposed to different fields including environmental science, as well as

zoning and planning.

Dr. Yelena Ogneva-Himmelberger, Project Advisor

# Academic History

**Name**: Tiancheng Ouyang                          **Date**: May 2017

**Place of Birth**: Hangzhou, Zhejiang, China       **Date**: February 13th 1992

**Baccalaureate School**: Wuhan University           **Date**: May, 2014

**Baccalaureate Subject**: B.Sc., Geographic Information System

**Occupation and Academic Connection** since Baccalaureate Degree: None

## Dedication

I dedicate this to my father, mother and my dear wife.

# ACKNOWLEDGEMENTS

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CHAPTER 1: INTRODUCTION

The Geographic Information Science for Development and Environment (GISDE) Master's program at Clark University has been crucial in determining my career choice. A completion of a GIS-intensive research or internship is required to graduate from this program. In the summer of 2016, I chose to work for the Massachusetts Department of Environmental Protection (MassDEP). The internship was proposed by Brian Postale, the Urban Compliance Initiative Project Coordinator, with the aim to produce a more automated and accurate means for data integration. The proposed duties were to aid in pulling together several aspects of environmentally related GIS and spreadsheet databases from MassDEP and the City of Worcester pertaining to Brownfields to identify areas of concern within District 4 of Worcester, MA. My experience with Python programming for GIS made me a great candidate for this internship. The internship was rather independent, as I was able to create my own schedule, making the work manageable from my point of view.

MassDEP has four regional offices. I worked for the Central Regional Office in Worcester, MA, under the supervision of Juliet Swigor, Regional GIS Coordinator, in collaboration with Mark Baldi, Deputy Regional Director MassDEP CERO Bureau of Waste Site Cleanup, Mike Leblanc and Matt Fitzpatrick, Environmental Analysts MassDEP CERO Bureau of Waste Site Cleanup, Kevin Daoust, Section Chief of MassDEP CERO Emergency Response, and Brian Postale, Manager of MassDEP CERO Engineering and Compliance. The internship proved a success in solving the issue, and I gained more knowledge about land parcels, hazardous waste and Python programming,

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and working at a governmental agency. This report will describe the organizational

structure of MassDEP, the role I played as an intern, and my evaluation of the experience.

CHAPTER 2: MISSION OF MASSDEP

MassDEP is an agency of the office of Energy and Environmental Affairs of

MassGIS that is responsible for protecting the state's environment. Its areas of

responsibility include preventing air, water, and ground pollution; protecting wetlands;

tackling waste and recycling issues; regulating hazardous materials; reducing climate

change. Their website states,

> "The Department of Environmental Protection - MassDEP - is the state agency
>
> responsible for ensuring clean air and water, the safe management of toxics and
>
> hazards, the recycling of solid and hazardous wastes, the timely cleanup of
>
> hazardous waste sites and spills, and the preservation of wetlands and coastal
>
> resources" (MassDEP, 2016).

The responsibilities of MassDEP are divided into six specific categories: clean air

and climate protection, recycling and reducing waste, waste sites and spills cleanup, toxics

reduction and hazards management, water resource protection, coasts and oceans.

2.1 MassDEP Organizational Structure

MassDEP consists of approximately 800 employees under the commission of

Martin Suuberg, who oversees nine managers. These include: Chief of Staff, Deputy

Commissioner for Operations and Environmental Compliance, Office of Municipal

Partnerships & Governmental Affair, Office of Permit and Regulatory Ombudsman and

Special Projects, Deputy Commissioner for Policy and Planning, Deputy Commissioner

for Administrative Services, General Counsel, Budgetary Affairs and Public Affairs.

There are six regional offices that undertake the tasks of the agency. These include

Northeast Regional Office in Wilmington, Central Regional Office in Worcester, Southeast

Regional Office in Lakeville, Western Regional Office in Springfield, Enterprise

Information Management Office and Office of Permit and Regulatory Ombudsman and

Special Projects. (MassDEP, 2016)

## 2.2 Geographic Information Science (GIS) and Mapping

GIS program within MassDEP includes GIS and mapping component, remote

sensing aspects and aerial photographs. The spatial datasets that MassDEP GIS Program

work with are mostly data published through MassGIS. This means whatever results come

out of the analysis/study are open to public. The spatial datasets compiled and managed by

the MassDEP GIS program are published through MassGIS, including: Public Water

Supply Sources and Protection Areas, Wetlands, Eelgrass Beds, Tier Classified 21e Sites

(MassDEP Tier Classified Oil and/or Hazardous Material Sites), BWP (the Bureau of

Waste Prevention) Facilities, Ground Water Discharge Permits, Non-Potential Drinking

Water Source Areas, and Areas Affected by Title V (Septic Systems Glossary). (MassDEP,

2016)

The GIS analysis involved in MassDEP is relatively simple in terms of geographic concept, as most tasks involve creating buffers, selecting by attributes/location, and spatial joining; however, in reality the results are usually complex and require actual knowledge in related fields to interpret and utilize, as most of them are about location of resources, hazardous waste or environmental threats. As a GIS department, the MassDEP GIS Program also produces maps to demonstrate the purpose of ongoing programs and projects.

## 2.3 MassDEP Strengths and Weakness

MassDEP has played an important role in guaranteeing people their right to clean air and water as well as a healthy environment. It is hard to evaluate their success, as their main role is to prevent environmentally harmful incidents from happening and contain those that have already happened. From a GIS and Remote Sensing standpoint, I would say their strengths lie in the fact that the data they are using is directly provided by upstream authorities, which represent a unified standard and detailed documentation. Even if data is unclear, it is easy to communicate with the data source to verify certain things.

Just as other government agencies face organizational problems, MassDEP has issues of inefficient communication. As a large institution, there are a lot of cases when information is passed back and forth among several departments just to have something clarified. For projects where people from different departments are involved, organizing a meeting has always been a challenge. All these factors have resulted in the inefficiency of task progress. Although the GIS program exists, most of the GIS work of a regional office

is usually conducted by the coordinator him/herself and a few interns. This leads to an extensive strain and disadvantage for the program and its opportunity to grow. GIS is regarded as a tool to deal with geographic related issues specifically coupled with other work, including table building or relating and online map illustrations that are completed through means of traditional programming. This imbalance between GIS capability and application can cause disadvantages for the MassDEP in terms of consistency.

CHAPTER 3: INTERNSHIP WITH MASSDEP

My internship responsibilities at MassDEP revolved around the Environmental Justice/Urban Initiative Project, which looks at several environmental factors affecting District 4 in Worcester, MA. The project includes joint collaborations between different agencies. Apart from MassDEP itself, the city of Worcester helped to develop methodologies and exchange relevant ideas and information in regards to the project.

As the intern, I was responsible for pulling together several aspects of environmentally related GIS and spreadsheet databases from MassDEP and the City of Worcester. This particularly pertains to Hazardous Waste Generators, other regulated facilities/sites designated for inspection, locations receiving complaints, AUL sites, Brownfields and other potential places of interest in order to help identify areas of concern within District 4 (see figure 1). The GIS and remote sensing portion of the work served only as subsidiary information for visualizing the locations of the features such as Brownfields and land parcels, to provide a better understanding of the project scale. Much of my work involved programming script-based ArcGIS tools (see below figures for

interfaces of the tools; codes are included in the appendix). I created tools to automate the

construction of an information warehouse in support of efforts to develop underutilized

properties within Worcester District 4 by integrating information stored in different GIS

data layers. Data was provided by MassDEP, also published through MassGIS websites.

Orthophotos that worked as reference of the parcels were pulled from MassGIS's Internal

Database.

       The goals of my internship was to provide means to extract information on a site-

specific basis for indexing. This will help to develop a site-specific index library that

would be used as informational clearinghouse for underutilized Brownfield properties.

This will help agencies like MassDEP to function more efficiently in terms of getting

information from sites and keeping better track of them.

Figure #1: Landuse and Brownfield Sites of District 4



**Landuse and Brownfield Sites of District 4**
**Worcester, Massachusetts**

Legend:
▲ Brownfield Sites

**Landuse**
- Residential
- Urban Public
- Industrial/Transportation
- Undeveloped/Natural
- Recreational

N

0.5    0.25    0    0.5 Miles

Map Created by Tiancheng Ouyang
Clark University February 23rd, 2017
Coordinate System NAD 1983 UTM Zone 19N
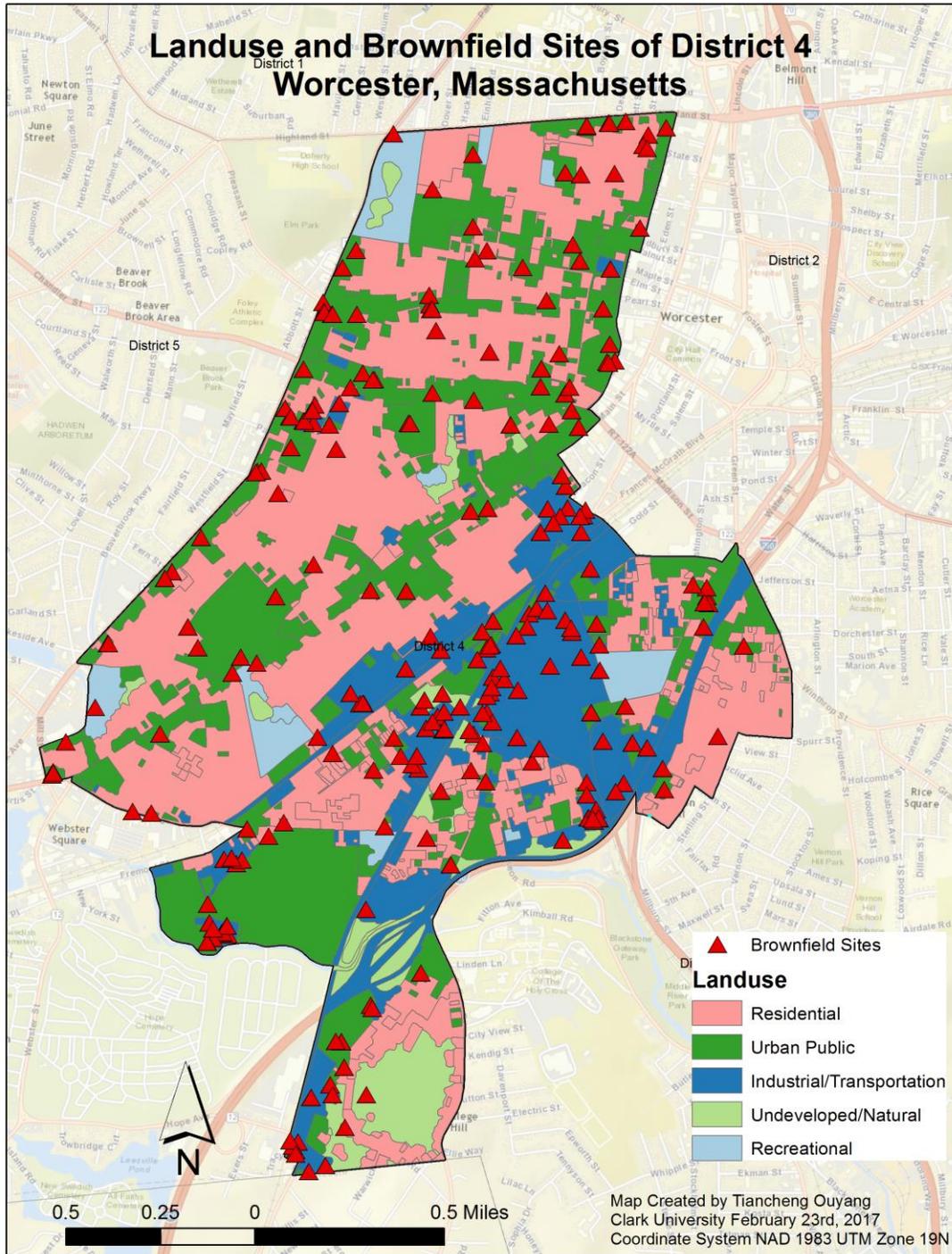
## 3.1 Spatial Join Tool

This tool provides batch processing of spatial joins. Under the circumstances of MassDEP, spatial join is mostly used to integrate basic information (parcel, environmental justice, wetland, zoning, etc.) to a data layer. Since preserving all the fields best serves the purpose of overviewing, field mapping is not necessary and thus not considered in this tool. The interface and parameter setting are shown in Figure 2 and Figure 3.

Figure #2: Interface of Spatial Join Tool
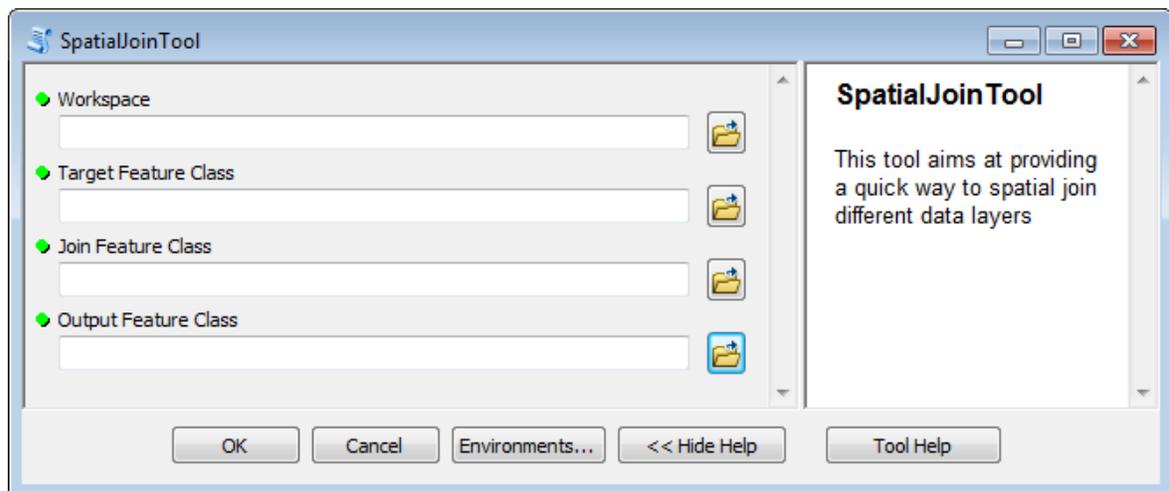
Figure #3: Parameter Setting of Spatial Join Tool
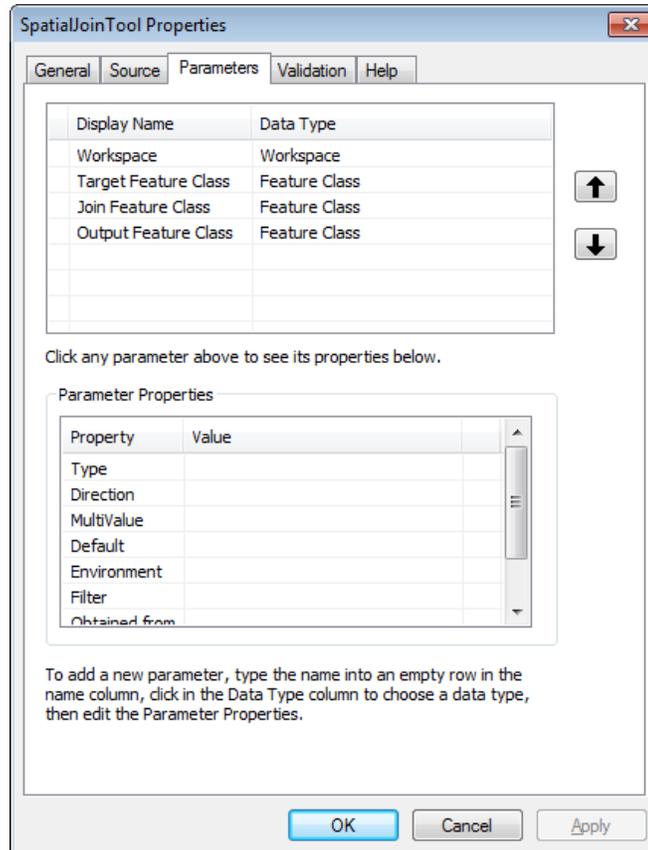


## 3.2 Clip Tool

This tool has a function of clipping all the feature classes stored in one path to a specified feature class. One of the first things I observed at MassDEP was that when starting a project within a certain geographic scale, the first stage would be to select all data layers involved by attribute according to the encoded ID (district, town/city, county, etc.). This was extremely time-consuming. Since all datasets used in MassDEP are published by MassGIS, they have a consistent geographical hierarchy. This precondition is crucial in my designation of the tool, as it prevents the misalignment of boundaries beforehand. The interface and parameter setting are shown in Figure 4 and Figure 5.

Figure #4: Interface of Clip Tool
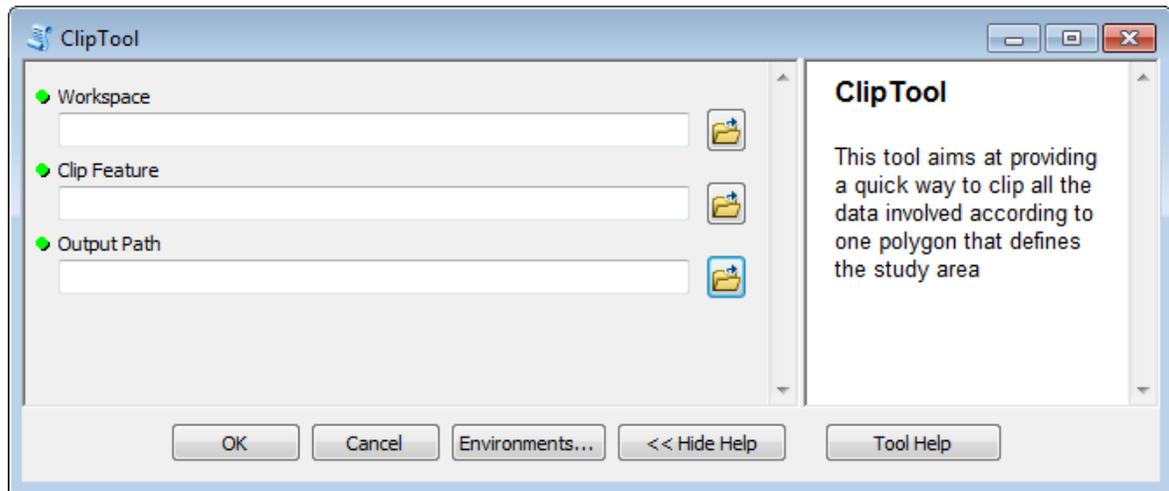
Figure #5: Parameter Setting of Clip Tool
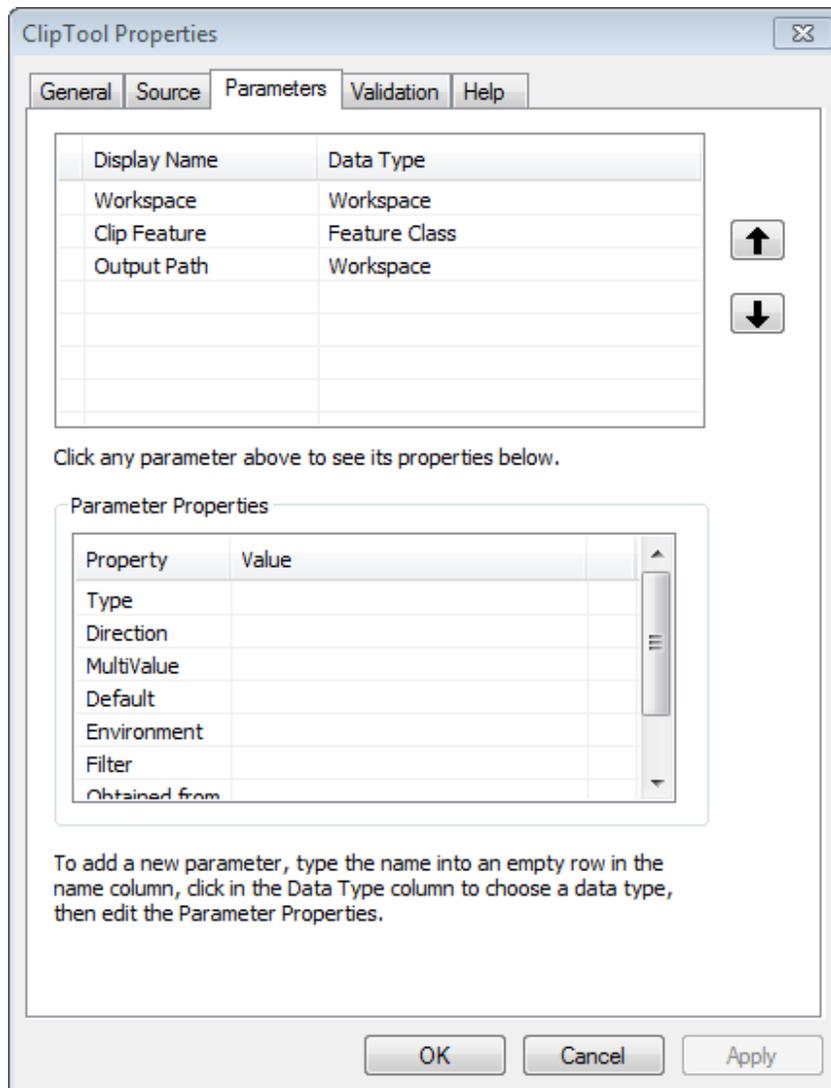


3.3 Check Address Tool

After the completion of the previously mentioned Spatial Join Tool, the Urban

Initiative project group asked me to use the tool to join the land parcel layer to the

brownfield sites layer. An example of attributes of the output is shown in Figure 6.

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Figure #6: Example attribute table of spatial join output (rearranged for display)

| OBJECTID_12 * | address | site_name | FULL_STR | ADDR_NUM |
|---|---|---|---|---|
| 1 | 530-541 PLEASANT STREET | ROADWAY RELEASE | PLEASANT ST | 530 |
| 2 | 25 WINTHROP ST | ST VINCENTS HOSPITAL | PROVIDENCE ST | 121 |
| 3 | 25 WINTHROP ST | ST VINCENTS HOSPITAL | PROVIDENCE ST | 121 |
| 4 | 27 GERMAIN ST | FRANCIS POTTER | GERMAIN ST | 27 |
| 5 | 233 SOUTHBRIDGE ST | CK SMITH TANK FARM | CHARLTON ST | 9 |
| 6 | 360 PARK AVE | DCJ COMPANY | PARK AVE | 360 |
| 7 | 25 QUINSIGAMOND AVE | COMMONWEALTH GAS CO | QUINSIGAMOND AVE | 19 |
| 8 | 55 SALISBURY ST | WORCESTER ART MUSEUM | SALISBURY ST | 55 |
| 9 | 779 MAIN ST | SUNOCO STATION | MAIN ST | 779 |
| 10 | 779 MAIN STREET | FORMER WORCESTER CAB | MAIN ST | 779 |
| 11 | 216 GRAFTON ST | AIELLO TRUST PROPERTY | GRAFTON ST | 220 |
| 12 | 216 GRAFTON ST | 85 GREEN ST TRUST | GRAFTON ST | 220 |
| 13 | 45 MCKEON RD | RILEY STOKER RESEARCH CTR | MCKEON RD | 45 |
| 14 | 36 UPSALA ST | UPSALA SCHOOL | UPSALA ST | 36 |
| 15 | 72 COES ST | CK COMPANY INC | COES ST | 72 |
| 16 | 1 APPIAN WAY | HOBBS FASTENERS | APPIAN WAY | 1 |
| 17 | 399 SOUTHBRIDGE ST | GETTY STATION FMR | SOUTHBRIDGE ST | 399 |
| 18 | RTE 290 EAST | VEHICLE ACCIDENT | | |
| 19 | 804 AND 852 SOUTHBRIDGE ST | NO LOCATION AID | SOUTHBRIDGE ST | 852 |
| 20 | 49 CANTERBURY ST | THOMAS SWEENEY | CANTERBURY ST | 49 |
| 21 | 85 GARDNER ST | SOUTH WORCESTER INDUSTRIAL PARK | CANTERBURY ST | 49 |
| 22 | 53-65 CANTERBURY ST 85 GARDNER | CITY OF WORCESTER | CANTERBURY ST | 49 |
| 23 | 3 CONGDON ST | N F SHELDON INC | CONGDON ST | 3 |
| 24 | 50 CANTON ST | CROMPTON PARK POOL | CANTON ST | |
| 25 | 125 PROVIDENCE ST | GIRLS CLUB | PROVIDENCE ST | 125 |
| 26 | 125 PROVIDENCE ST | GIRLS INC | PROVIDENCE ST | 125 |
| 27 | 501 PARK AVE | MARANE BULK TERMINAL | PARK AVE | 501 |
| 28 | 501 PARK AVE | MARINE OIL CO | PARK AVE | 501 |
| 29 | 501 PARK AVE | MARANE OIL CORP | PARK AVE | 501 |
| 30 | 501 PARK AVE | MARANE FACILITY | PARK AVE | 501 |
| 31 | 501 PARK AVE | ABS BRAKE SHOP | PARK AVE | 501 |
| 32 | 65 GRAFTON ST | GRAFTON ST SUBSTATION | GRAFTON ST | 65 |
| 33 | 418-440 CAMBRIDGE ST | ESTATE OF LEROY P SMITH | CAMBRIDGE ST | 418 |
| 34 | 340 FRANKLIN ST | CONSOLIDATED FREIGHTWAYS | | |
| 35 | 207 GRAFTON ST | AGGREGATE INDUSTRIES | | |
| 36 | 5 BARBARA LN | PARCEL 2A-2B UST REMOVAL | | |
| 37 | 17 MECHANIC ST | MID TOWN MALL | FRONT ST | 22 |

Table — BWSC_Clipped_Joined

1 ► ►| (0 out of 678 Selected)

BWSC_Clipped_Joined

The group would like to see whether the addresses recorded in the brownfield sites layer and the land parcel layer match or not. In order to address this problem, I designed the Check Address Tool to split address fields from both layer and compare each element. Specifically, in Figure 5, the field "address" represents the address recorded in the brownfield sites layer, and the field "FULL_STR" represents the address recorded in the land parcel layer. For example, for the first record, "530-541 PLEASANT STREET" in

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"address" field would be splited into "530-541", "PLEASANT" and "STREET",

"PLEASANT STREET" in "FULL_STR" field would be split into "PLEASANT" and

"STREET". "530-541" would be compared with "530" in "ADDR_NUM" tool, while the

two "PLEASANT" would be compared to each other. The tool would create three fields

named "Street_Mat", "Num_Match" and "All_Match", each recording if the corresponding

element match or not by putting "Y" or "N". The interface and parameter setting are shown

in Figure 7 and Figure 8.


Figure #7: Interface of Check Address Tool
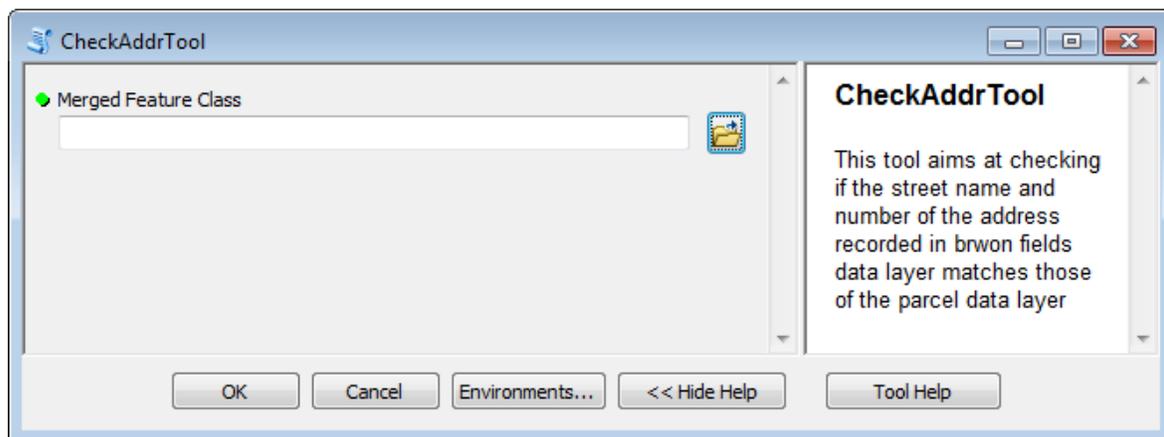
Figure #8: Parameter Setting of Check Address Tool
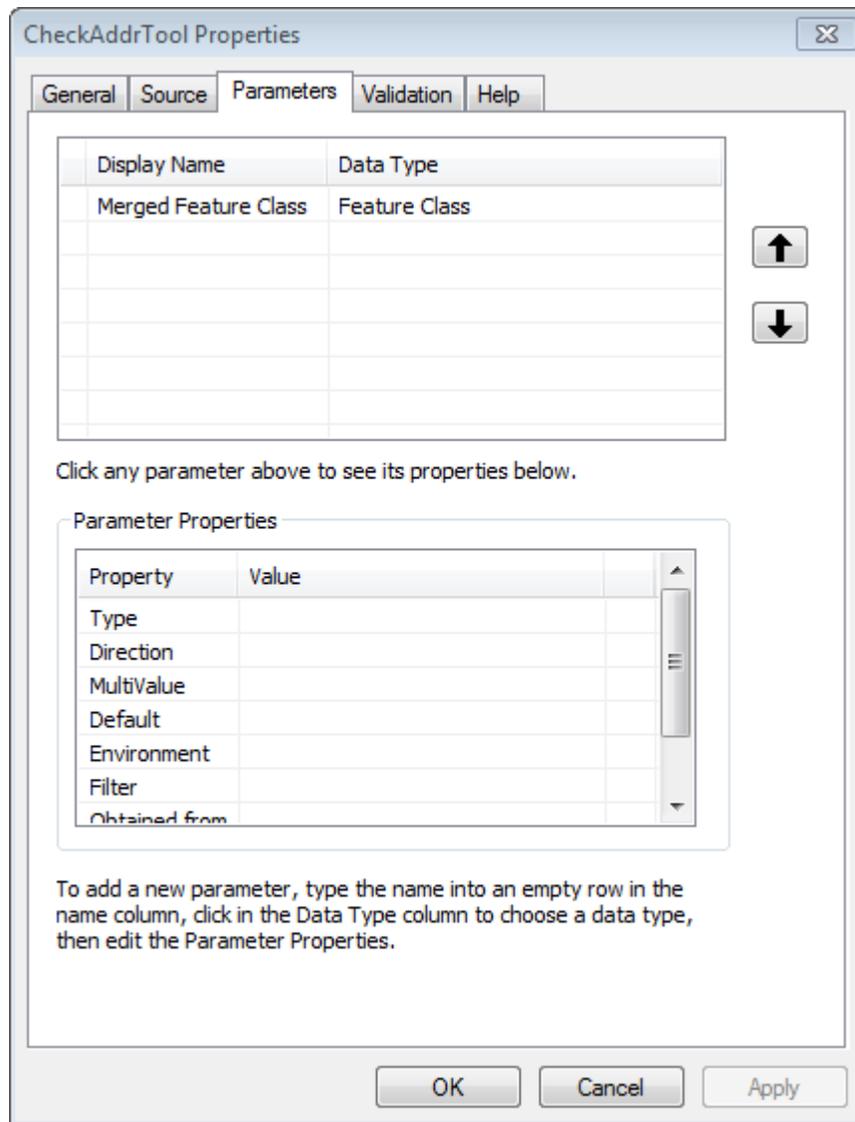


3.4 Multi Define Tool

The Urban Initiative Group also needed a quick way to check if a Brownfield site

falls in certain type of land (environment justice area, wetland area, etc.). For this reason, I

designed the Multi Define Tool. The tool takes the feature class that needs to be checked as

well as a path as input. The path should contain all the land type feature classes. The tool

will then run intersect between the data layers contained in the path with the feature class

that needs to be checked and create a field with the same name as each layer and put "Y"

or "N" to record if each record intersects with this particular land type. The interface and

parameter setting are shown in Figure 9 and Figure 10.

Figure #9: Interface of Multi Define Tool
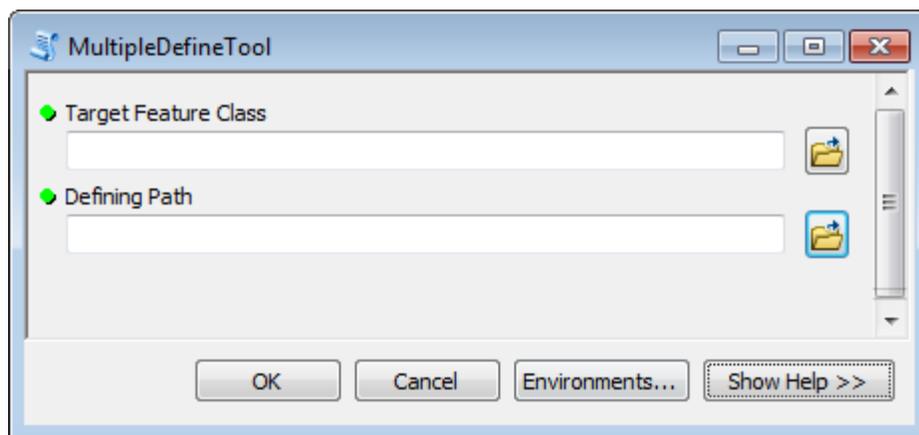
Figure #10: Parameter Setting of Multi Define Tool
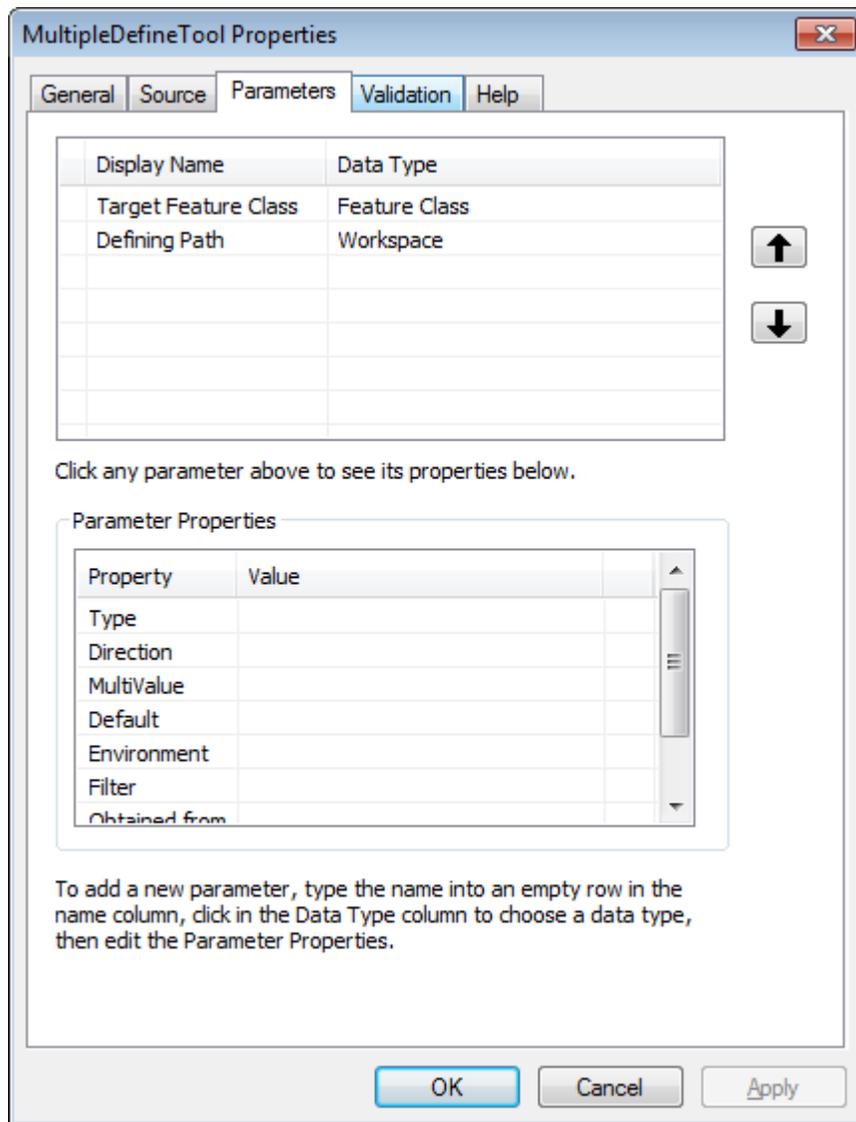


### 3.5 Zoning Summary Tool

For the purpose of generating individual report of Brownfield Sites, the Urban

Initiative Group would like a tool that can summarize the percentages of the zoning types

each Brownfield Site covers. The coverage is based on pre-made buffers around each site.

Since there was not a specific buffer distance determined by the time this tool was

finished, it is set to take a path where all individual buffer feature classes are stored as

input. Each buffer will be used to clip the input land use feature class which will be

generated in the specified "Feature Output Path". The tool will also produce dbf tables that

contain percentages of the zoning types covered in the "Individual Table Path" for each

buffer. Finally, a summary table will be produced integrating all individual tables together.

The interface and parameter setting are shown in Figure 11 and Figure 12.

Figure #11: Interface of Zoning Summary Tool
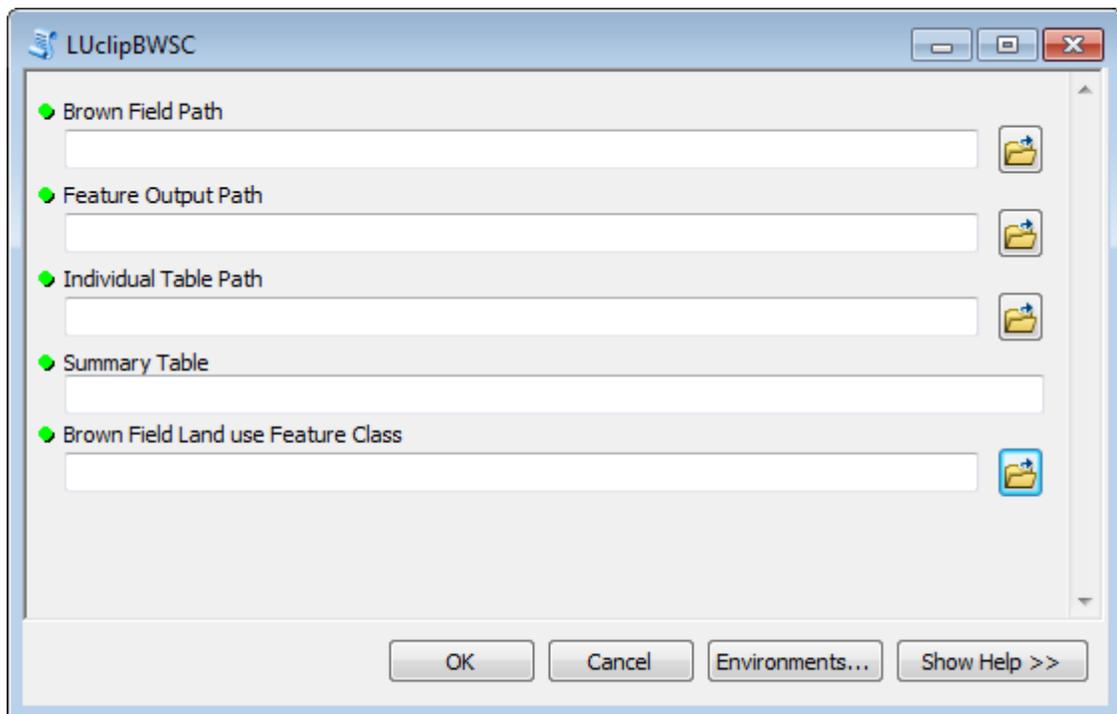
Figure #12: Parameter Setting of Zoning Summary Tool
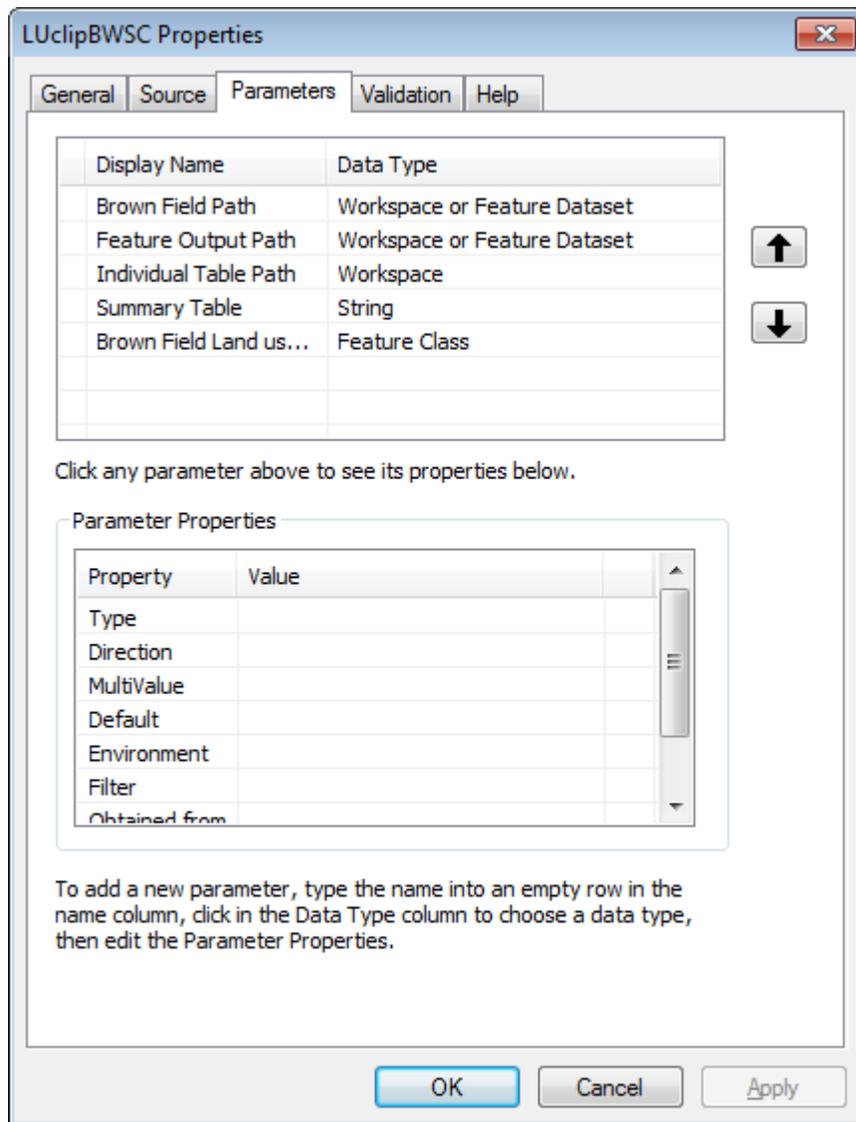


CHAPTER 4: INTERNSHIP ASSESSMENT

The internship at MassDEP was a meaningful experience that helped consolidate

and stimulate my educational and professional goals. It provided me a great opportunity to

apply the knowledge and skills learned at Clark to real-world issues. Understanding social

and environmental issues, their relationships to administrative initiatives and working with government officials from different fields proved to be a dynamic and instrumental aspect of the internship. It broadened my horizon from a student's perspective to the professional world. My experience gained at the MassDEP was vital to my future. Being able to articulate myself in meetings, practice time management, and work with unfamiliar real-world issues were invaluable lessons. My internship has undoubtedly served as a necessary experience in helping me decide my future after graduate school.

Clark University was very influential in preparing me for the internship at the MassDEP. The skills learned at Clark through classes and course projects played an important role in strengthening my qualification for the internship. These skills included an understanding and familiarity with GIS and cartography, their related softwares, and experience working with scripting languages (e.g. Python). Other equally important skills were the ability to teach myself new knowledge, to work individually, and to articulate ideas through presentations and discussions. The combination of these skills was helpful throughout the internship, especially because I was the only intern in the program and the instructions from the group were ambiguous. The Python programming classes I have taken were extremely beneficial throughout the internship. Most of the work required prior experience and knowledge with programming, use of language packages (e.g. os, sys, string and arcpy) and familiarity with the debugging and optimizing procedures of tools.

The MassDEP internship also provided the opportunity to develop new, on-the-job technical and social skills. Skills I acquired on the technical side of my internship included: the responsibilities as the program intern, abbreviations and acronyms used in the DEP

work environment, and necessary information required in dealing with the brown field sites. These aspects needed to be learned relatively fast. Since there were not many chances of meeting during the internship, the ability to come up with tasks and gain information through emails had to be picked up as soon as possible to allow time for the programming procedure. The social aspect came into play when I would meet with members in charge of different programs from the MassDEP who were important in the urban initiative project. A challenging part of the internship was to explain the functions of the programmed tools in a way that an audience with no background in GIS could understand. It did however provide me the opportunity to practice and develop better communication skills with colleagues.

CHAPTER 5: CONCLUSION

Clark University has been extremely helpful in preparing me for my future career in GIS field. The wide range of high quality courses provided through the program has granted me many opportunities, one of them being the summer internship at MassDEP. The internship is not without its flaws, yet it proved to serve as an invaluable experience connecting academic experiences and professional dynamics. It allowed me to apply the skills learned at Clark, particularly those directly associated with programming. Besides the program's context of environmental protection, its urban aspect was beneficial, as I would like to develop my future career towards GIS applications in the urban dimension. The projects and people were both terrific, allowing me to deepen my understanding of how different aspects of information are integrated together through GIS and how useful

proper programming can be during the process. I feel grateful for this experience and to the people who have been a great help during that time. I hope to remain a part of this project in the future, and I would recommend this internship to other IDCE students who have an interest in working on issues related to the environmental cause.

APPENDIX: Tool Source Code (Python)

I. Spatial Join Tool

```
import arcpy

arcpy.env.overwriteOutput = True

workspace = str(arcpy.GetParameterAsText(0))

target_fc = str(arcpy.GetParameterAsText(1))

join_fc = str(arcpy.GetParameterAsText(2))

out_feature_class = str(arcpy.GetParameterAsText(3))

arcpy.SpatialJoin_analysis(target_fc, join_fc, out_feature_class)
```

II. Clip Tool

```
import arcpy

arcpy.env.overwriteOutput = True

path = str(arcpy.GetParameterAsText(0))

arcpy.env.workspace = path

outpath = str(arcpy.GetParameterAsText(2))

clip_fc = str(arcpy.GetParameterAsText(1))


for fc in arcpy.ListFeatureClasses():

    outfc = outpath + "\\" + arcpy.Describe(fc).baseName + "_Clipped"

arcpy.Clip_analysis(fc, clip_fc, outfc)
```

III. Check Address Tool

```python
import arcpy

import arcpy.da

arcpy.env.overwriteOutput = True

target_fc = str(arcpy.GetParameterAsText(0))

arcpy.AddField_management(target_fc, "Street_Mat", "TEXT")

arcpy.AddField_management(target_fc, "Num_Match", "TEXT")

arcpy.AddField_management(target_fc, "All_Match", "TEXT")

with arcpy.da.UpdateCursor(target_fc, ["address", "ADDR_NUM",
"FULL_STR", "Street_Mat", "Num_Match", "All_Match"]) as cursor:

    for row in cursor:

        if row[2] is not None:

            if " " in row[0] and " " in row[2]:

                fieldElements = row[0].split(" ")     #Split

                fieldElements2 = row[2].split(" ")

                if fieldElements[0] == row[1]:

                    row[4] = "Y"

                else:

                    row[4] = "N"        #Compare addr number

                if fieldElements[1] == fieldElements2[0]:

                    row[3] = "Y"

                else:

                    row[3] = "N"        #Compare street name
```

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```
                        if row[3] == "Y" and row[4] == "Y":

                            row[5] = "Y"

                        else:

                            row[5] = "N"

                        cursor.updateRow(row)

IV. Multi-Define Tool

        import arcpy

        import arcpy.da

        arcpy.env.overwriteOutput = True

        target_fc = str(arcpy.GetParameterAsText(0))

        input_path = str(arcpy.GetParameterAsText(1))

        arcpy.env.workspace = input_path

        define_fcList = arcpy.ListFeatureClasses('', 'Polygon')

        FieldNameList = {'EJ', 'WETLAND'}

        for fieldname in FieldNameList:

            fieldList = arcpy.ListFields(target_fc, fieldname)

            fieldCount = len(fieldList)

            if fieldCount == 1:

                arcpy.DeleteField_management(target_fc, fieldname)

            arcpy.AddField_management(target_fc, fieldname, "TEXT")

            lyr = arcpy.Describe(target_fc).baseName + "_lyr"

            arcpy.MakeFeatureLayer_management(target_fc, lyr)
```

```
    arcpy.SelectLayerByLocation_management(lyr, 'intersect', fieldname +

'.shp')

    with arcpy.da.UpdateCursor(lyr, [fieldname]) as cursor:

        for row in cursor:

            row[0] = "Y"

            cursor.updateRow(row)

    arcpy.SelectLayerByLocation_management(lyr, 'intersect', fieldname + '.shp',

"", "SWITCH_SELECTION")

    with arcpy.da.UpdateCursor(lyr, [fieldname]) as cursor:

        for row in cursor:

            row[0] = "N"

            cursor.updateRow(row)
```

V.  LUclipBWSC Tool

```
    # Import system modules

    import sys, string, os, shutil

    import arcpy

    from arcpy import env

    env.overwriteOutput = True

    #adapting for batch land use clip and summary

    print "Processing..."

    # Check availability of appropriate ArcGIS license

    # Set required ESRI code:
```

```python
try:

    if arcpy.CheckProduct("arcview") == u"Available":

        arcpy.SetProduct("arcview")

        print "  " + "Esri Arcview product license set"

    #elif arcpy.CheckProduct("arceditor") == u"Available":

        #arcpy.SetProduct("arcinfo")

    else:

        msgLicenseDNE="No ESRI ArcView licenses available to run script"

        raise Exception, msgLicenseDNE

except Exception, ErrorDesc: print ErrorDesc




#Retrieve parameters

workspace = str(arcpy.GetParameterAsText(0))

OutPathA = str(arcpy.GetParameterAsText(1))

OutPathB = str(arcpy.GetParameterAsText(2))

OutTable = str(arcpy.GetParameterAsText(3))

BasinLU = str(arcpy.GetParameterAsText(4))

#Set workspace

arcpy.env.workspace = workspace

#Make list of subbasin feature classes
```

```
BasinList = arcpy.ListFeatureClasses()

length = len(BasinList)

#Add and calculate an Area_M item to the basin impervious surface feature

class

arcpy.management.AddField(BasinLU, 'Area_M', "DOUBLE")

exp = "!SHAPE.AREA@SQUAREMILES!"

arcpy.management.CalculateField(BasinLU, "Area_M", exp, 'PYTHON_9.3')

del exp

#Build output table

arcpy.AddMessage("Building output summary table")

#Create empty table

summTab = arcpy.management.CreateTable(OutPathB, OutTable)

#Add fields to table

arcpy.management.AddField(summTab, 'AU_ID', "TEXT", '', '', '12')

arcpy.management.AddField(summTab, 'TotArea', "DOUBLE")

arcpy.management.AddField(summTab, 'ResArea', 'DOUBLE')

arcpy.management.AddField(summTab, 'UndevArea', 'DOUBLE')

arcpy.management.AddField(summTab, 'IndArea', 'DOUBLE')

arcpy.management.AddField(summTab, 'UrbArea', 'DOUBLE')

arcpy.management.AddField(summTab, 'RecArea', 'DOUBLE')

arcpy.management.AddField(summTab, 'PercRes', "FLOAT", '5', '1')

arcpy.management.AddField(summTab, 'PercUndev', "FLOAT", '5', '1')
```

```
arcpy.management.AddField(summTab, 'PercInd', "FLOAT", '5', '1')

arcpy.management.AddField(summTab, 'PercUrb', "FLOAT", '5', '1')

arcpy.management.AddField(summTab, 'PercRec', "FLOAT", '5', '1')

#Cycle through basins

for b in BasinList:

#Extract basin name from file name

    if '.shp' in str(b):

        NList = string.split(str(b), '.')

        name = NList[0]

    else:

        name = str(b)

#Show progress on screen

    arcpy.AddMessage('Clipping ' + name)

#Clip land use by sub basin

    subLU = arcpy.analysis.Clip(BasinLU, b, OutPathA + '\\LU_' + name)

    exp = "!SHAPE.AREA@SQUAREMILES!"

    arcpy.management.CalculateField(subLU, 'Area_M', exp, 'PYTHON_9.3')

    outName = 'Sum_LU_' + name + '.dbf'

#Display progress on screen

    arcpy.AddMessage('Building ' + outName + ' table')

#Create individual table for basin

    indivTable = arcpy.analysis.Statistics(subLU, OutPathB + '\\' + outName,
```

```python
                        [['Area_M', 'SUM']], "LU_Summ")

#Add individual subBasin areas to summary table

    sCurse = arcpy.SearchCursor(indivTable)

    iCurse = arcpy.InsertCursor(summTab)

#Extract land use areas from table

    fieldList = []

    for row in sCurse:

        if row.LU_Summ == '1':

            area1 = row.SUM_Area_M

            fieldList.append('Residential')

        if row.LU_Summ == '2':

            area2 = row.SUM_Area_M

            fieldList.append('Undeveloped')

        if row.LU_Summ == '3':

            area3 = row.SUM_Area_M

            fieldList.append('Industrial')

        if row.LU_Summ == '4':

            area4 = row.SUM_Area_M

            fieldList.append('Urban')

        if row.LU_Summ == '5':

            area5 = row.SUM_Area_M

            fieldList.append('Recreation')
```

```python
#Insert row into summary table

newRow = iCurse.newRow()

#Check to see if each land use type exists in basin

if 'Residential' in fieldList:

    newRow.ResArea = area1

else:

    newRow.ResArea = 0

if 'Undeveloped' in fieldList:

    newRow.UndevArea = area2

else:

    newRow.UndevArea = 0

if 'Industrial' in fieldList:

    newRow.IndArea = area3

else:

    newRow.IndArea = 0

if 'Urban' in fieldList:

    newRow.UrbArea = area4

else:

    newRow.UrbArea = 0

if 'Recreation' in fieldList:

    newRow.RecArea = area5

else:
```

```python
    newRow.RecArea = 0

  newRow.AU_ID = name

  iCurse.insertRow(newRow)

  del sCurse, iCurse, newRow, fieldList
#Calculate percentage fields in summary table
totExp = "!ResArea! + !UndevArea! + !IndArea! + !UrbArea! + !RecArea!"
arcpy.management.CalculateField(summTab, "TotArea", totExp,

"PYTHON_9.3")


Exp1 = "!ResArea! / !TotArea! * 100"

arcpy.management.CalculateField(summTab, "PercRes", Exp1,

"PYTHON_9.3")

Exp2 = "!UndevArea! / !TotArea! * 100"

arcpy.management.CalculateField(summTab, "PercUndev", Exp2,

"PYTHON_9.3")

Exp3 = "!IndArea! / !TotArea! * 100"

arcpy.management.CalculateField(summTab, "PercInd", Exp3,

"PYTHON_9.3")

Exp4 = "!UrbArea! / !TotArea! * 100"

arcpy.management.CalculateField(summTab, "PercUrb", Exp4,

"PYTHON_9.3")

Exp5 = "!RecArea! / !TotArea! * 100"
```

```python
arcpy.management.CalculateField(summTab, "PercRec", Exp5,

"PYTHON_9.3")

del totExp, Exp1, Exp2, Exp3, Exp4, Exp5

#replace _ in AU_ID with -

Cursor = arcpy.UpdateCursor(summTab)

#Loop through rows in cursor to update the fields

for row in Cursor:

    if '_' in row.AU_ID:

        auID = row.getValue('AU_ID')

        idList = auID.split('_')

        auName = idList[0] + '-' + idList[1]

        row.AU_ID = auName

#Update LU_Summ field

    Cursor.updateRow(row)

#Delete initial empty field

arcpy.management.DeleteField(summTab, ["Field1"])

del Cursor, summTab
```

# BIBLIOGRAPHY

MassDEP-Massachusetts Department of Environmental Protection. Accessible Link:

http://www.mass.gov/eea/agencies/massdep/.Last accessed on: December 11 2016