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| Lab Assignment 2  **Intervention Modeling for Water Functional Planning** |

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| **Section** | **Assigned** | **Due** |
| **AB** | **4/10** | **4/17** |
| **AA** | **4/11** | **4/18** |

Lab policy: <http://courses.washington.edu/geog464/guidelines_win2017.html>

Lab schedule: <http://courses.washington.edu/geog464/labschedule_17.html>

Canvas: <https://canvas.uw.edu/courses/1152834>

**1.0 Introduction**

Previously, you were introduced to functional plans and comprehensive plans. By definition, a function is a purpose or activity of something, e.g. the function of a water system, or more particularly stormwater system. Because many people value water as an important resource, many stakeholder groups value (storm)water resource planning as an important activity. The purpose of water is to provide liquid sustenance to humans, animals (e.g., salmon), plants, etc., as a basic constituent of life. The function of a habitat is to provide a safe place to nurture health, e.g. a home. Fish habitats require water; some functions are more basic than others. A functional plan commonly focuses on a single theme, e.g. a plan for a water system which might be associated with various functions. Water quantity (flow) and water quality are sub-functions of water, but we can still call them functions. An important point to remember is that levels of performance for functions should be measurable as in water flow or water quality measurements which have processed within lab assignment 1.

A comprehensive plan focuses on multiple functional themes. For example, within the WA State Growth Management Act (GMA) there are eight elements (we call them functions or functional themes: land use, housing, transportation, rural and resource lands, park and recreation, capital facilities, utilities, and economic) are fundamental to all counties and cities in Washington State as mandated by GMA law. Notice however, that water is not listed among the elements? Why not? It is part of the Shoreline Management Act (all rivers, lakes, and marine environments of the state). Since land use and transportation activities interact with each other every day at many scales, they are mandated by GMA law to be considered in relation to one another, which is called concurrency management. Any single function (theme) might influence any other function (theme). However, there is no legislated law that mandates how people (communities) must consider the relationships among the other elements. For example, how land resource use and water resource use should be considered in connection with each other. Nonetheless, it makes a lot of sense to many people that we recognize interaction between land use and water. Why? Land use is a major influence on water shortage and quarter quality problems. Thus, science, engineering, particular organizations, and practical problems all encourage us to look at these inter-relationships as they occur, even though they are not mandated within law.

Functional and comprehensive plans are developed at local, regional and national-scales to consider intentional changes in conditions, whether these are for improvement or not, in anticipation of what we might expect for the future. A plan map can be considered a ‘spatial-temporal statement of goals’ for the future. There are two types of approaches to develop plans. One is called forecast planning wherein driving force conditions of the future are forecasted and functional element conditions are brought in line with those driving forces to establish a ‘best case’, given the conditions. Another type of planning is called backcast, wherein conditions of functional elements are established as a goal, and then conditions are brought in line to reach that goal. Obviously, macro-scale forcing conditions are at play within backcast as well, so the functional element conditions take those into consideration. Most planning is undertaken using forecasting, as hindcasting is a bit harder. However, many sustainability management activities try to use a backcast planning approach because ‘goal setting’ is quite important in planning. What kinds of goals might we set for protecting and/or restoring water function across the landscape? WA Dept of Ecology has characterized the importance and degradation conditions in comparison to pristine conditions; this is a kind of backcast. You set the goal, and then see how to reach it. We will use our approach to assessments from lab assignment 1 to understand conditions in order to develop three scenarios for planning. The three scenarios are baseline conditions (as given by Ecology data), better conditions and worse conditions than the baseline.

Learning Objectives:

1. Develop an intervention strategy using a change model, impact, model and decision model. Propose three change scenarios (baseline, better, and worse) that respond to the assessment evaluation in lab 1.
2. Become familiar with scenario development
3. Compute the impacts for scenarios
4. Choose among the three scenarios using impact information and describe the trade-offs that were considered in the decision model.
   1. **Data from Lab 1**

The data outcomes from Lab 1 for each WRIA have been assembled and are available for you to download. During the lab presentation on best data and project practices you were encouraged to create a new geodatabase for each lab and populate it with just the data you expect to use. Treat this data download as having completed this action. It is unlikely that everyone did the lab the same way and have identical data outcomes following Lab 1 for Lab 2. We ask you to use the provided geodatabase for your WRIA so everyone will have the same data as you begin Lab 2. Remember to choose the geodatabase that matches the same WRIA you used in Lab assignment 1.

You will find these files on Canvas in this folder: <https://canvas.uw.edu/courses/1152834/files/folder/lab/data/Lab2_restart>

WRIA 7: Lab2\_WRIA7.zip

WRIA 8: Lab2\_WRIA8.zip

WRIA 9: Lab2\_WRIA9.zip

Download and extract the files to a new empty Lab2 working folder. Remember: ArcMap cannot read files from inside a zip archive.

Create a new empty ArcMap project and save it to your Lab 2 working folder then load the data from your WRIA'.

* 1. **Data requirements**

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| * [WF\_RP] – The water flow feature class from the Department of Ecology used in Lab 1 with the calculated fields and joined fields from WQ\_RP * [WQ\_RP] – The water quality feature class from the Department of Ecology with the calculated fields from Lab 1 * [WFWQ] – The cleaned up output feature class of the subwatershed from the join between WF\_RP and WQ\_RP on the field AU\_ID. It has the fields WF\_RP, WF\_order, WFstnd, PA\_RP, WQ\_order, WQstnd and WFI. * [city\_kc\_dslv] – The jurisdictions of King County dissolved to single record multi-part polygons. * [evaluation] – The spatial join of jurisdictions and subwatershed and has the average WFI values for each jurisdiction * WFWQ\_order – The look-up table used to assign order data values to the subwatershed RP categories. |  |

**2.0 Geodesign Intervention Modeling for Water Planning**

Geodesign intervention modeling is composed of three sub-modeling steps, change modeling, impact modeling and decision modeling.

**2.1 Geodesign change model for water planning**

In lab assignment 1 we performed an assessment of water function, creating a water function index (composed of water flow and water quality) using an evaluation model and output to a feature class named [evaluation].We mapped the index for all sub-watersheds using satisfactory and good levels in the table below, with the thresholds developed in the context of pristine conditions.

Table 1: Thresholds for condition of functional performance

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Performance threshold level | Name | RP | RP code | Order | Standardized |
| Lowest level | Conservation | D1 | L,H | 1 | 1 |
| Satisfactory level | Restoration/Development | RD2 | M,MH | 6 | 33 |
| Good level | Protection | P2R | MH,M | 11 | 66 |
| Highest level | Highest Protection | P1 | H,L | 16 | 100 |

The thresholds in Table 1 can be used to establish interval ranges of performance, e.g. three interval ranges of data that are of interest. An interval range with data values 1-33 can be considered a ‘below satisfactory’ condition of functional performance. An interval range with data values 34-66 can be considered a ‘satisfactory’ condition of functional performance. An interval range with data values 67-100 can be considered an ‘above satisfactory’ condition of functional performance.

That information provides us insight about a ‘baseline scenario’ for plan development from the Dept of Ecology. We could say, those below satisfactory, satisfactory, and above satisfactory conditions are reasonable from the point of view of Dept of Ecology as a regulatory agency. Let us call that current data a ‘baseline scenario’ for the future. However, there are other ways to look at conditions, particularly if we consider public stakeholders. Maybe those are not the most preferred conditions by the community of stakeholders who will make a decision about the water function plan, i.e. the WRIA consortium partners. So, we create a scenario as a set of assumptions about ‘goal’ conditions that are more preferred. Using a change model we can compose a view of ‘alternative goal conditions’ for sub-watershed areas. A map of the collection of these changes can be considered an alternative scenario (map plan) for the future.

One way to develop a change model is to establish different conditions (that is, different data values) for ‘satisfactory’ and ‘above satisfactory’ (aka better conditions) of performance, or ‘below satisfactory’ (aka worse conditions) of performance. Basically, three alternative scenarios can be identified, baseline conditions, better conditions, or worse conditions.

Baseline conditions: Data values do not change into the future from what Ecology originally computed. However, this does not mean that nothing is done. In fact, with urban development on the increase, it is harder to sustain the current conditions because mitigation is still needed to avoid harm. Nonetheless, we will disregard this nuance for now, and maintain the data thresholds as they have been provided in the Ecology database, although they lead to more realistic scenarios.

Better conditions: If we are seeking overall better conditions in relation to pristine, add data units to the WF and WQ condition threshold, thereby improving the condition expectation of sub-watersheds by X units (some number between 1-16 as ordered) or Y units (standardized between 1-100). We thus expect higher goals, more pristine condition, for the future. Note: The number of units could not be greater than ‘5’ order units or 33 standardized units because we cannot do better than ‘pristine’.

Worse conditions: subtract from the condition data units, thereby degrading the condition of sub-watersheds by X units (ordered) or Y units (standardized). We would subtract WF and WQ data units, thereby reducing our water condition expectation. We thus expect higher goals, more pristine condition, for the future.

In Lab assignment 1 were processed different perspectives about assessment using a map visualization approach. Although that approach is useful for assessment of conditions, it is not as relevant for change modeling because the map visualization does not change the data values within the database. As such, we will use a database approach in this assignment to create a change model. For this change model, each of the scenario baseline, better, and worse, will have three interval levels below satisfactory, satisfactory and above satisfactory for WF and WQ (as well as the combination). However, what makes the scenarios different is that the condition levels for below satisfactory, satisfactory, and above satisfactory are different among the scenarios.

2.1.1 Database approach to change model scenarios

The feature class WFWQ has the fields WF\_RP and PA\_RP that were used with the look-up table WFWQ\_order.dbf to make WF\_order and WQ\_order with a data range value 1-16. You prepared this in Lab 1 section 4.1 after consulting the category code descriptions in figures D-14 and D-19 in [Appendix D: Geospatial Methods for the Water Resource Assessments](https://fortress.wa.gov/ecy/publications/parts/1106016part4.pdf). Read the category code descriptions associated with the below satisfactory, satisfactory, and above satisfactory conditions to better understand their makeup. Now, you need to decide on the amount of change to water flow (WF\_order) and water quality (WQ\_order) that would realize the better and worse scenarios. You will want to justify your choice of specification (change) relative to the category code descriptions. The rest of the lab assignment will refer to your choice of change to attain the better scenario as ‘B\_spec’ and the change to attain the worse scenario ‘W\_spec’.

2.1.1.1 Create the data for the better scenario. Tools used: [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342), [SELECT BY ATTRIBUTES](https://canvas.uw.edu/courses/1152834/discussion_topics/3773819)

Export feature class WFWQ to a new feature class named ‘better’ and open the attribute table. Use [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) to calculate the values for the field WF\_order using this equation: [WF\_order] + B\_spec. Remember, B\_spec is the change you decided was needed to realize the better scenario. Repeat [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) to calculate values for WQ\_order using this equation: [WQ\_order] + B\_spec.

You want to keep the values of WF\_order and WQ\_order in the range 1-16. Use [SELECT BY ATTRIBUTES](https://canvas.uw.edu/courses/1152834/discussion_topics/3773819) to select records using this equation: [WF\_order] > 16. Use [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) to set WF\_order of the selected records to 16. Do the same for WQ\_order so there are no records with values greater than 16. Be sure to clear the selection before you continue.

Use the following equation in [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) to calculate WFI for the better scenario:

((100.0 \* (([WF\_order] - 1) / 15.0)) + (100.0 \* (([WQ\_order] - 1) / 15.0))) / 2.0

2.1.1.2 Create the data for the worse scenario

This is the exact same procedure as for the better scenario except subtracting your W\_spec value from the order fields and adjusting for order values that fall below 1.

Export feature class WFWQ to a new feature class named ‘worse’ and open the attribute table. Use [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) to calculate the values for the field WF\_order using this equation: [WF\_order] - W\_spec. Remember, W\_spec is the change you decided was needed to realize the worse scenario. Repeat [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) to calculate values for WQ\_order using this equation: [WQ\_order] - W\_spec.

You want to keep the values of WF\_order and WQ\_order in the range 1-16. Use [SELECT BY ATTRIBUTES](https://canvas.uw.edu/courses/1152834/discussion_topics/3773819) to select records using this equation: [WF\_order] < 1. Use [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) to set WF\_order of the selected records to 1. Do the same for WQ\_order so there are no records with values less than 1. Be sure to clear the selection before you continue.

Use the following equation in [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) to calculate WFI for the worse scenario:

((100.0 \* (([WF\_order] - 1) / 15.0)) + (100.0 \* (([WQ\_order] - 1) / 15.0))) / 2.0

Note that this equation takes the values from WF\_order and WQ\_order, standardizes them and then takes their average that is the WFI. This step bundles together the steps to standardized WF\_order and WQ\_order as WFstnd and WQstnd that you did in Lab 1. The standardization equation is built into the averaging equation here to reduce the number of times you have to use CALCULATE FIELD.

2.1.2 Mapping the scenarios

Map WFI for each of the three scenarios using the thresholds in Table 1 that define the conditions ‘below satisfactory’, ‘satisfactory’ and ‘above satisfactory’.

Mapping the condition scenario in this way is an opportunity to consider these questions. When the water function composed of water flow and water quality sum to a level above satisfactory, then one or the other of WF or WQ or both WFI are above the satisfactory level. If one of the data values is high and makes up for the other data value, then we say the measure is ‘compensatory’. That is, a good performance level of water flow can make up for a poor performance level of water quality on a data unit by data unit (1 for 1) basis, or vice versa. We will assume that water flow is compensatory with water quality.

**2.2 Geodesign impact model for water planning**

In a regional plan, we really never know exactly how much will be the total outcome, but a general estimate can be made. What is the impact of the change scenarios being proposed? To answer that question we need information about area. We do this is two ways below: 1) impacts on sub-watersheds across the WRIA, and 2) impacts on sub-watersheds with each jurisdiction.

2.2.1 Impacts on Sub-watersheds across the WRIA. Tools used: [ADD FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757336), [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342), [SUMMARIZE TABLE](https://canvas.uw.edu/courses/1152834/discussion_topics/3773869)

What is the total area above the satisfactory range of water function for sub-watersheds in your WRIA for the baseline, better and worse condition scenarios? To know this the subwatersheds must be evaluated using the performance threshold levels in Table 1.

Use [ADD FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757336) to add a text field named ‘performance’ to each scenario’s feature class: baseline (feature class ‘WFWQ’), better (feature class ‘better’) and worse (feature class ‘worse’). Populate the values of ‘performance’ using [CALCULATE FIELD](https://canvas.uw.edu/courses/1152834/discussion_topics/3757342) using the following Python code in the ‘Field Calculator’ dialog:

|  |  |
| --- | --- |
| Make sure the Parser is set to ‘Python’.  Check the ‘Show Codebook’ checkbox.  Copy/paste this code into the ‘Pre-logic Script Code’  def reclass(wfi):  if wfi < 34:  return "below satisfactory"  elif (wfi > 33) and (wfi) < 67:  return "satisfactory"  else:  return "above satisfactory"  Copy/paste this code into the ‘performance=’ field:  reclass( !WFI!)  Click ‘ok’ |  |

This little Python snippet reads the WFI field and returns a value into ‘performance’ relative to the threshold levels from Table 1.

To determine the total (sum) area of each ‘performance’ category in each scenario use [SUMMARIZE TABLE](https://canvas.uw.edu/courses/1152834/discussion_topics/3773869) to create a summary table for each scenario of the total (sum) area of the ‘performance’ categories. Name them according to their scenario, i.e. better\_area, worse\_area, baseline\_area.

Map the ‘performance’ for each scenario and report the area of the performance categories.

2.2.2 Impacts on Sub-Watersheds for each Jurisdiction. Tools used: [SELECT BY ATTRIBUTES](https://canvas.uw.edu/courses/1152834/discussion_topics/3773819), [SPATIAL JOIN](https://canvas.uw.edu/courses/1152834/discussion_topics/3757329)

To appreciate the relationship of the scenarios for the jurisdictions in the WRIA you want to report the total area above the satisfactory range of water function for sub-watersheds for each jurisdiction. This is more detailed information than merely a sub-watershed. You already used [SPATIAL JOIN](https://canvas.uw.edu/courses/1152834/discussion_topics/3757329) in Lab 1 to calculate the average WFI for the subwatersheds in each jurisdiction and may want to review that portion of the Lab 1 instructions.

To restrict the join to just the subwatersheds with a ‘performance’ of ‘above satisfactory’ use [SELECT BY ATTRIBUTES](https://canvas.uw.edu/courses/1152834/discussion_topics/3773819) where performance = 'above satisfactory'. Records that are not selected will be ignored. You need these parameters for the [SPATIAL JOIN](https://canvas.uw.edu/courses/1152834/discussion_topics/3757329):

Target features: city\_kc\_dslv

Join features: a scenario feature class with selected records

Join operation: JOIN\_ONE\_TO\_ONE

Keep all target features: unchecked

Field map: set the Merge rule for the field ‘area’ to SUM.

Match option: Intersect

Choose useful names for the output feature classes like baseline\_performance, better\_performance, worse\_performance.

Inspect the results to insure you have the expected outcome from the SPATIAL JOIN and are prepared to answer the questions that follow.

**2.3 Geodesign decision model for water planning**

How would we address trade-offs among the proposed changes and rank the scenarios so that we can set a priority for a plan?

Which of the better, worse, or baseline scenarios should be selected? Why?

Consider the following:

Will more area of concern require more effort and/or expense?

Will less area of concern require less effort and/or expense?

Is the baseline scenario as a science-based effort be the one that should be used?

What if Water flow and Water quality were of different importance?

Given the total revenue potential for each jurisdiction, what areas are likely going to need more help with addressing the problem? That is, some jurisdictions have lots of potential to restore, but not so much revenue to address restoration?

Consider trade-offs with regard to impacts. If we seek to address the better, worse or baseline conditions, what jurisdictions benefit more or less?

**3.0 Composing an Essay**

Write an essay about describing which of the plan(s) might work best for the WRIA consortium.

What is your interpretation of these plans? Where are the improvements generally expected? In the uplands or the lowlands or in-between? Why?

Given the different perspectives of the Consortium members in regards to where they are located in the WRIA, why would that plan work?

Are any members more favored; that is, is there resource base more favored for improvement of the various components?

Take a jurisdiction and study it in more detail. How does this perspective change the outcome of your choice about which scenario to recommend?

**4.0 Deliverables**

Plan map for each of three scenarios as per section 2.1.2

Map WFI for each of the three scenarios using the thresholds in Table 1 that define the conditions ‘below satisfactory’, ‘satisfactory’ and ‘above satisfactory’.

Impact maps as per section 2.2.1

Map the ‘performance’ for each scenario and report the area of the performance categories.

An essay interpreting the plan scenarios