CVEN 6345

Water Quality Modeling/Monitoring

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Part 3-C

**Station 10599**

Aalok Sharma Kafle

Station 10599 (Pine Is Bayou at LNVA Pump St) is located at 30.169987N and 94.154517W in River Section 0607 (Pine Island Bayou). The basin properties and river characteristics of this subbasin along with all other basins on the upstream are tabulated below, where Lca is length along the channel to the centroid of the area.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Watershed Name** | **Watershed Area** sq. miles | **Length** miles | **Lca** miles | **Slope** %-Rise | **Slope** ft/mile |
| 10599 | 12.74 | 3.9 | 3.8 | 1.74 | 91.87 |
| 10602 (C749) | 312.29 | 17.2 | 19.4 | 1.11 | 58.61 |
| 10607 | 293.19 | 31.0 | 16.2 | 0.64 | 33.79 |
| 15367 | 89.13 | 21.0 | 10.7 | 0.90 | 47.52 |

National Land Cover Database (NLCD) is then used to get following properties:

|  |  |  |  |
| --- | --- | --- | --- |
| **Watershed Name** | **% Developed** | **% Impervious** | **SCS Curve Number** |
| 10599 | 23.29 | 7.95 | 84.2 |
| 10602 (C749) | 9.16 | 2.15 | 86.2 |
| 10607 | 4.69 | 1.01 | 85.6 |
| 15367 | 0.52 | 0.32 | 89.3 |

Now, looking at all types of land cover for the subbasin 10599 (12.74 sq. miles), the distribution of various types of lands is tabulated below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land Type** | **% Cover** |  | **Land Type** | **% Cover** |
| Open Water | 2.29 |  | Mixed Forest | 1.59 |
| Developed, Open Space | 8.83 |  | Shrub/Scrub | 1.09 |
| Developed, Low Intensity | 8.24 |  | Herbaceous | 1.40 |
| Developed, Medium Intensity | 4.45 |  | Hay/Pasture | 1.59 |
| Developed, High Intensity | 1.78 |  | Cultivated Crops | 0.10 |
| Barren Land | 0.09 |  | Woody Wetlands | 59.77 |
| Evergreen Forest | 5.15 |  | Emergent Herbaceous Wetlands | 3.63 |

Evidently, the sub basin has a higher proportion of developed land at 23.29%, while most of the region are woody wetlands, at 59.77%. If we look at the landcover of other basins on the upstream (i.e., 10602, 10607, and 15367) on Appendix A, they also contain a significant portion of Forests and Hay/Pasture.

Now for the analysis of the water quality data for the station, we have non-continuous data of various parameters dated between 08/25/1987 to 03/02/2022. To find the abnormal data on the stream station, the following water quality parameters are used as defined on ***2022 Texas Integrated Report – Assessment for Basin 6 - Neches River***. In the report, station 10599 is identified as Assessment Unit 01 for River Segment 607 (AU\_ID : 0607-01).

Table Water Quality Criteria for AU\_ID 0607\_01

|  |  |
| --- | --- |
| **Parameter** | **Criteria** |
| Dissolved oxygen Grab | 5 |
| Nitrate (Domestic Water Use) | 10 mg/L |
| Total Dissolved Solid | 300 mg/L |
| Sulfate | 50 mg/L |
| Chloride | 150 mg/L |
| High pH | 8.5 |
| Low pH | 6 |
| Total Phosphorous | 0.69 mg/L |
| Nitrate (Aquatic Life Use) | 1.95 mg/L |
| Chlorophyll-a | 14.1 |
| Ammonia | 0.33 mg/L |
| Water Temperature | 35 C |
| E. Coli (Recreation Use) | 126 colonies/100ml |

Some other quality parameters whose data were available were also accessed for abnormality based on the criteria set by various sources. The Criteria for Specific Metals and Organic Substances in Water for Protection of Aquatic Life developed by TCEQ, present for this station along with some other parameters are tabulated below.

|  |  |
| --- | --- |
| **Parameter** | **Maximum Allowable Concentration** |
| Total Kjeldahl Nitrogen | 0.33 mg/L (TCEQ) |
| Nitrate plus Nitrite | 1.95 mg/L (TCEQ) |
| Phosphorous (Orthophosphate) | 0.1 mg/L as P (Mackenthun 1973) |
| Alkalinity, Low | 20 mg/L |
| Alkalinity, High | 400 mg/L |
| Aluminum (1988 Recommendation) | 750 µg/L |
| Aluminum (2018 Revision) | 1 – 4800 µg/L (EPA) |
| Hardness (moderately hard) | 75 mg/L |
| Arsenic (human use) | 10 µg/L |
| Arsenic (aquatic use) | 70 µg/L (TCEQ) |
| Barium | 1000 µg/L |
| Cadmium, acute | 1.8 µg/L (EPA 2023) |
| Chromium, acute | 16 µg/L (EPA 2023) |
| Mercury, acute | 1.4 µg/L (EPA 2023) |
| Nickel | 470 µg/L (EPA 2023) |
| Iron, domestic use | 0.3 mg/L (USEPA 1976) |
| Iron, freshwater aquatic life | 1.0 mg/L(USEPA 1976) |
| Manganese, fish consumption | 100 µg/L (USEPA 1976) |
| Lead, acute freshwater | 65 µg/L (EPA 2023) |
| Selenium | 8.5 µg/L (USEPA 1976, Beaman 2016) |
| Silver | 3.2 µg/L (Stephan, Mount et al. 1985) |

**Total Kjeldahl Nitrogen**

It can be present in water from various sources such as organic matter, debris, sewage, fertilizers, animal waste, and agricultural runoff. (Chavez 2022) The allowable limit for this parameter is 0.33 mg/L.

**Alkalinity**

The Chemical Concentration Criterion(CCC) for alkalinity is 20 mg/L, the minimum amount for it to be considered as healthy water. Even concentrations as high as 400 mg/L are not considered to pose a danger to human or environmental health (Anderson, Nagar et al. 2007).

**Aluminum**

EPA recommends that it is advised to ensure that the one-hour average concentration of aluminum does not surpass 750 µg/L more than once every three years on average, when the ambient pH lies between 6.5 and 9.0. This is recommended to prevent acute toxicity and ensure protection. (Gostomski 1990) However, 2018 revision by EPA has provided this criterion to be between 1 and 4800 µg/L based on the water chemistry of the site. For our station, nationally recommended criteria of 750 µg/L is considers.

**Hardness**

In general, hardness is not considered toxic to aquatic life, but extremely high levels of hardness can have negative impacts on aquatic organisms. The level of toxicity can vary depending on the specific species and environmental conditions. Classification of water by hardness content classifies water above 75 mg/L as hard water, so it is considered as criteria for our location. Natural source of hardness principally are limestones which are dissolved by percolating rainwater which again shows up as surface water downstream. (USEPA 1976)

**Arsenic**

Concentration 5 µg/L representing nominal background concentration and 10 µg/L representing the EPA Maximum Contaminant Level for human. (Robert C. Reedy 2018) For aquatic use, 70 µg/L is recommended for section 0607.

**Barium**

EPA has recommended MCL for Barium to be 1000 µg/L, originally published on the 1976 Red Book of water quality (USEPA 1976).

Based on these criteria, the data from station 10599 was analyzed, and the **excel sheet is attached** with this report.

Calendar

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The number of exceedances for various parameters are listed below:

|  |  |
| --- | --- |
| **Parameter** | **Number of exceedances** |
| NITROGEN, AMMONIA, TOTAL (MG/L AS N) | 1 |
| OXYGEN, DISSOLVED (MG/L) | 4 |
| PH (STANDARD UNITS) | 4 |
| PHOSPHATE, TOTAL (MG/L AS PO4) | 1 |
| E. COLI, COLILERT, IDEXX METHOD, MPN/100ML | 17 |

Evidently, E. Coli is of major importance here while trying to understand the water quality data of this subbasin. E. Coli as a non- point source can be occurring from various sources.

1. **Agricultural runoff:** Contaminated water from livestock and poultry operations, as well as manure and fertilizer applications, can lead to E. coli contamination in nearby water bodies.
2. **Wildlife and domestic animals:** Wild animals and domestic pets can carry and shed E. coli bacteria into the environment, where it can contaminate water and soil.
3. **Faulty septic systems:** Septic systems that are not functioning properly or are poorly maintained can release E. coli bacteria into the environment, contaminating nearby water sources.
4. **Stormwater runoff:** Heavy rain events can wash E. coli bacteria from surfaces such as streets, parking lots, and rooftops into storm drains and nearby waterways.
5. **Human waste:** Improperly treated sewage can discharge E. coli bacteria into water bodies, posing a risk to public health.

Now, looking at various sources of E. Coli and cross checking them with the land cover of this region, the exceedances may have been caused by the developed lands on the region producing human wastes, faulty waste disposal system with leakages and corresponding stormwater runoffs.

To analyze the relation between the quality parameter and flow, first flow data is necessary for each measurement of E. Coli. Two types of flow data are available in the quality data.

* Flow Stream, Instantaneous (cubic feet per sec)
* Stream flow Estimate (cfs)

For the data points were instantaneous flow data is not available, it is filled with the stream flow estimate values and a table is prepared with Available Stream Flow Data and E. Coli Measurement for that day.

Now, plotting the available flow data and E. Coli on a time series plot gives following result:

Although rise in flow does not always seem to exactly increase the concentration of E. Coli, we see some distinct time period where flow increase is resulting in higher levels of E. Coli. This can be because of the runoff from the developed region bringing in E. Coli through places like faulty septic tanks, or other pollutions spread across the watershed. The **Pearson Correlation** of **Available Flow(>0) and E. Coli(>0)** is calculated to be **0.4186.**

Next, if the data points which only have instantaneous flow are analyzed separately, the X-Y plot of Flow and E. Coli concentration is observed as below. The **Pearson Correlation** of **Instantaneous Flow(>0) and E. Coli(>0)** is calculated to be **0.5657**. It is because the instantaneous flow is measured at the same time and location as the E. Coli measurement, so it shows more correlation when compared to the flow estimate.

Now focusing on specific time-period of 02/14/2018 and 01/14/2021, this part of the data can be extracted separately (for non-negative flows) and plotted on a time series graph.

For **this time-period of data**, the **Pearson Correlation** rises to **86.7%.**

**References**

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USEPA (1976). Quality criteria for water. EPA 440/9-76-023, DC Washington.

**Appendix A**

Landcover by percentage and SCS Curve Number

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **15367** | | | | | |
| **Land type Code** | **COUNT** | **NLCD Land Type** | **% Cover** | **CN** | **Weighted CN** |
| 11 | 68 | Open Water | 0.03 | 100 | 0.03 |
| 21 | 6942 | Developed, Open Space | 2.70 | 79 | 2.13 |
| 22 | 1120 | Developed, Low Intensity | 0.44 | 82 | 0.36 |
| 23 | 203 | Developed, Medium Intensity | 0.08 | 86 | 0.07 |
| 24 | 12 | Developed, High Intensity | 0.00 | 93 | 0.00 |
| 31 | 17 | Barren Land | 0.01 | 88 | 0.01 |
| 41 | 821 | Deciduous Forest | 0.32 | 79 | 0.25 |
| 42 | 98815 | Evergreen Forest | 38.44 | 85 | 32.68 |
| 43 | 39552 | Mixed Forest | 15.39 | 82 | 12.62 |
| 52 | 9442 | Shrub/Scrub | 3.67 | 83 | 3.05 |
| 71 | 17349 | Herbaceous | 6.75 | 80 | 5.40 |
| 81 | 6981 | Hay/Pasture | 2.72 | 78 | 2.12 |
| 90 | 71129 | Woody Wetlands | 27.67 | 86 | 23.80 |
| 95 | 4581 | Emergent Herbaceous Wetlands | 1.78 | 83 | 1.48 |
| *TOTAL* | *257032* |  | *100* |  | **83.99** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **10607** | | | | | |
| **Land type Code** | **COUNT** | **NLCD Land Type** | **% Cover** | **CN** | **Weighted CN** |
| 11 | 2360 | Open Water | 0.28 | 100 | 0.28 |
| 21 | 21574 | Developed, Open Space | 2.55 | 79 | 2.02 |
| 22 | 14092 | Developed, Low Intensity | 1.67 | 82 | 1.37 |
| 23 | 3188 | Developed, Medium Intensity | 0.38 | 86 | 0.32 |
| 24 | 784 | Developed, High Intensity | 0.09 | 93 | 0.09 |
| 31 | 472 | Barren Land | 0.06 | 88 | 0.05 |
| 41 | 1034 | Deciduous Forest | 0.12 | 79 | 0.10 |
| 42 | 111097 | Evergreen Forest | 13.15 | 85 | 11.18 |
| 43 | 112384 | Mixed Forest | 13.31 | 82 | 10.91 |
| 52 | 15769 | Shrub/Scrub | 1.87 | 83 | 1.55 |
| 71 | 16625 | Herbaceous | 1.97 | 80 | 1.57 |
| 81 | 199965 | Hay/Pasture | 23.68 | 78 | 18.47 |
| 82 | 20073 | Cultivated Crops | 2.38 | 86 | 2.04 |
| 90 | 298032 | Woody Wetlands | 35.29 | 86 | 30.35 |
| 95 | 27106 | Emergent Herbaceous Wetlands | 3.21 | 83 | 2.66 |
| *TOTAL* | *844555* |  | *100* |  | **82.96** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **10602 (C749)** | | | | | |
| **Land type Code** | **COUNT** | **NLCD Land Type** | **% Cover** | **CN** | **Weighted CN** |
| 11 | 3136 | Open Water | 0.35 | 100 | 0.35 |
| 21 | 45143 | Developed, Open Space | 5.02 | 79 | 3.96 |
| 22 | 24770 | Developed, Low Intensity | 2.75 | 82 | 2.26 |
| 23 | 10130 | Developed, Medium Intensity | 1.13 | 86 | 0.97 |
| 24 | 2322 | Developed, High Intensity | 0.26 | 93 | 0.24 |
| 31 | 592 | Barren Land | 0.07 | 88 | 0.06 |
| 41 | 723 | Deciduous Forest | 0.08 | 79 | 0.06 |
| 42 | 230107 | Evergreen Forest | 25.58 | 85 | 21.74 |
| 43 | 118932 | Mixed Forest | 13.22 | 82 | 10.84 |
| 52 | 41901 | Shrub/Scrub | 4.66 | 83 | 3.87 |
| 71 | 41184 | Herbaceous | 4.58 | 80 | 3.66 |
| 81 | 62839 | Hay/Pasture | 6.99 | 78 | 5.45 |
| 82 | 3906 | Cultivated Crops | 0.43 | 86 | 0.37 |
| 90 | 297074 | Woody Wetlands | 33.03 | 86 | 28.40 |
| 95 | 16750 | Emergent Herbaceous Wetlands | 1.86 | 83 | 1.55 |
|  | 899509 |  |  |  | **83.79** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Basin 10599** | | | | | |
| **Land type Code** | **COUNT** | **NLCD Land Type** | **% Cover** | **CN** | **Weighted CN** |
| 11 | 844 | Open Water | 2.29 | 100 | 2.29 |
| 21 | 3254 | Developed, Open Space | 8.83 | 79 | 6.97 |
| 22 | 3038 | Developed, Low Intensity | 8.24 | 82 | 6.76 |
| 23 | 1640 | Developed, Medium Intensity | 4.45 | 86 | 3.83 |
| 24 | 657 | Developed, High Intensity | 1.78 | 93 | 1.66 |
| 31 | 32 | Barren Land | 0.09 | 88 | 0.08 |
| 42 | 1899 | Evergreen Forest | 5.15 | 85 | 4.38 |
| 43 | 588 | Mixed Forest | 1.59 | 82 | 1.31 |
| 52 | 403 | Shrub/Scrub | 1.09 | 83 | 0.91 |
| 71 | 517 | Herbaceous | 1.40 | 80 | 1.12 |
| 81 | 588 | Hay/Pasture | 1.59 | 78 | 1.24 |
| 82 | 38 | Cultivated Crops | 0.10 | 86 | 0.09 |
| 90 | 22036 | Woody Wetlands | 59.77 | 86 | 51.40 |
| 95 | 1337 | Emergent Herbaceous Wetlands | 3.63 | 83 | 3.01 |
|  | 36871 |  |  |  | **85.03** |

**Station 10599 (Segment 607)**

**Pine Island Bayou Subbasin**

**Relationship between Water Quality Parameters**

Chart, waterfall chart

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**Relationship of Water Quality Parameters with Flow**

|  |  |
| --- | --- |
| **Parameter** | **Correlation with Flow** |
| Alkalinity | 0.072 |
| Chloride | 0.038 |
| E. Coli | -0.236 |
| Hardness | -0.12 |
| Nitrite | -0.221 |
| Nitrogen | -0.021 |
| DO | 0.105 |
| pH | 0.199 |
| Phos | 0.038 |
| Sp. Condu. | 0.176 |
| Temp | 0.044 |