



**PRAIRIE VIEW A&M UNIVERSITY**

A Member of the Texas A&M University System

**ASSESSMENT REPORT  
FOR  
CVEG 4301: ENVIRONMENTAL ENGINEERING DESIGN**

**Instructor**

**Dr. Raghava Rao Kommalapati, Ph.D., PE, BCEE, F. ASCE**

**Department of Civil and Environmental Engineering  
Roy G. Perry College of Engineering  
Prairie View A&M University**

**Fall 2021**



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**CVEG 4301– Environmental Engineering Design  
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**Table of Contents**

1. Cover Page
2. Detailed Course Syllabus (ABET Format Plus HB2504 Format)
3. End of Semester Outcomes Assessment Report
4. Grade Sheet Showing Student and Class Performance in Outcomes
5. Supporting Outcome Specific Assignments
  - 5.1 An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
  - 5.2 an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors



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**Detailed Course Syllabus  
&  
Course Syllabus in ABET Format**



## CVEG 4301: Environmental Engineering Design Fall 2021

### General Course Information

| Information Item               | Information                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Instructor:</b>             | Raghava R. Kommalapati, PhD, PE, BCEE, F. ASCE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Section # and CRN:</b>      | CVEG 4301 P01 & CRN 17737                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Office Location:</b>        | 110J Wilson Bldg (Also check my other Office (CEES) - 206T Wilson Bldg                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Office Phone:</b>           | 936 261 1660                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Email Address:</b>          | <a href="mailto:rrkommalapati@pvamu.edu">rrkommalapati@pvamu.edu</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Office Hours:</b>           | Tu, Th 9.30 to 11am, and Mondays 1-4 pm and other hours with prior arrangement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Mode of Instruction:</b>    | <b>Face to Face</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Course Location:</b>        | 109G Wilson Engineering Building                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Class Days &amp; Times:</b> | Tu, Th: 11 am-12:20 pm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Catalog Description:</b>    | Synthesis of environmental engineering fundamentals into an integrated system design, which includes the design of physical, chemical, and biological unit operations and processes in water and wastewater treatment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Prerequisites:</b>          | CVEG 3301 (old # CVEG 3043)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Co-requisites:</b>          | None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Required Text(s):</b>       | Introduction to Environmental Engineering, 5th ed., Davis & Cornwell, McGraw-Hill, 2013, ISBN 978-0-07-340114-0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Recommended Text(s):</b>    | <ol style="list-style-type: none"><li>1. Water and Wastewater Engineering: Design Principles and Practice, Davis, McGraw Hill, 2020, ISBN 978-1-260-13227-4</li><li>2. Water Quality, Tchobanoglous and Schroeder, Addison-Wesley, 1985</li><li>3. Water Treatment Principles and Design, 3rd ed., MWH, Crittenden, Trussell, Hand, Howe and Tchobanoglous 2012, John-Wiley &amp; Sons</li><li>4. Water and Wastewater Technology, 6th ed, Hammer and Hammer, 2008, Prentice Hall.</li><li>5. Water Supply and Pollution Control, 8th ed, Viesman, Hammer Perez and Chadik, 2009, Prentice Hall.</li><li>6. Water Treatment Unit Processes: Physical and Chemical, Hendricks, 2006, CRC Press.</li><li>7. Wastewater Engineering, 5th edition, Metcalf and Eddy, 2014, McGraw-Hill</li><li>8. Unit Operations and Processes in Environmental Eng., 2nd ed., Reynolds, 1996 PWS-KENT (ISBN: 053494884-7)</li></ol> |

### Course Goals or Overview:

The goal of this Course is to provide fundamental knowledge of water and wastewater treatment processes and the design of various processes for treating water and wastewater to meet the regulatory standards.

### Estimated ABET Category Content

Engineering Science: 1 credit or 33%

Engineering Design: 2 credits or 67%

## Student Learning Outcomes:

|   | Upon successful completion of this Course, students will be able to:      | Program Learning Outcome # Alignment* | Core Curriculum Outcome Alignment |
|---|---------------------------------------------------------------------------|---------------------------------------|-----------------------------------|
| 1 | Comprehend the fundamentals of environmental engineering                  | ABET 3 (1)                            |                                   |
| 2 | Determine the water requirements for a municipality or water district     | ABET 3 (1,2)                          |                                   |
| 3 | Determine the waste volumes from a development or a municipality          | ABET 3 (1,2)                          |                                   |
| 4 | design physical and chemical treatment methods for water                  | ABET 3 (1,2,3)                        |                                   |
| 5 | design physical, chemical and biological treatment methods for wastewater | ABET 3 (2)                            |                                   |
| 6 | understand contemporary issues related to water/ wastewater treatment     | ABET 3 (2)                            |                                   |
| 7 | Research and complete a design project                                    | ABET 3 (1,2,3)                        |                                   |

## Outcome Measures

| Course    | CVEG Objectives* |   |   |   | ABET Criterion 3-Student Outcomes* |   |   |   |   |   |   |
|-----------|------------------|---|---|---|------------------------------------|---|---|---|---|---|---|
|           | 1                | 2 | 3 | 4 | 1                                  | 2 | 3 | 4 | 5 | 6 | 7 |
| CVEG 4301 | X                | X | X | X | M                                  | M | R |   |   |   |   |

**X** means the Program Objective is achieved

**M** means that the skills described in the program outcome are measured in the Course.

**R** means the described outcome is reinforced but not measured and could be monitored.

\* The Civil Engineering Program Learning Outcomes are derived from ABET Criterion 3 (Student Outcomes) Civil Engineering Program Educational Objectives (PEOs) and student learning outcomes are provided at the end of this course outline (Page 14). **Items in Bold are measured**

## Major Course Requirements & Evaluation Methods

Students will be evaluated based on their performance in class examinations, homework, quiz, design project and presentation, and class attendance and participation in discussions. ABET Criteria 3(1, 2) would be measured for this Course.

| Course Grade Requirement              | Percent of Final Grade |
|---------------------------------------|------------------------|
| 1. Homework, Quiz & other Assignments | 15                     |
| 2. Three Exams                        | 48                     |
| 3. Design Project                     | 15                     |
| 4. Final Exam                         | 22                     |
| 5. Class Participation & Discussion   | -10*                   |
| <b>Total:</b>                         | <b>100</b>             |

\* Attendance: The university attendance policy notwithstanding, the overall grade is subject to be discounted up to 10% for lack of attendance and participation.

### Grading Criteria and Conversion:

A = >90%

B = 80-89.5%

C = 70-79.5%

D = 60-69.5%

F = <60%

### Detailed Description of Major Assignments:

|                                |                                                                                                                                                                  |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Homework:</b>               | There will be 6-8 homework assignments that will be assigned, and you need to submit them on the due date.                                                       |
| <b>Exams (including Final)</b> | 3 exams and a final will be given                                                                                                                                |
| <b>Design Project</b>          | A design project will be assigned at the beginning of the class and students are required to design a water or wastewater treatment plant.                       |
| <b>Quizzes</b>                 | Quizzes will be given as and when needed to keep the students fully prepared for each class. Additionally, these quizzes will help to prepare students for exams |

### Topics to be Covered

1. Review of Environmental Engineering Fundamentals
2. Water and wastewater Quantities
3. Introduction to design
4. Water Treatment Processes and Design
5. Wastewater Treatment Processes and Design
6. Advanced Processes for Water and Wastewater Treatment

### Course Procedures or Additional Instructor Policies

- **Taskstream:** Taskstream is a tool that Prairie View A&M University uses for assessment purposes. One of your assignments may be required to be submitted as an "artifact," an item of coursework that serves as evidence that course objectives are met. If applicable, more information will be provided during the semester by your department, but for general information, you can visit Taskstream via the link in eCourses.
- The student should provide proper documentation to justify an excused absence ahead of time and in case of emergencies as soon as possible (do not wait for the next class time).
- Late homework will not be accepted unless you make prior arrangements with the instructor.
- Professionalism includes class conduct and participation in class. Unprofessional classroom behavior will not be tolerated.
- **The cell phone** cannot be a substitute for the calculator. If a **cellphone or other gadgets are either open or used during the exam/quiz or other assignments, then the assignments will be marked zero credit.**
- Any and every electronic gadget (except for approved calculators) cannot be used in the class without prior approval from the instructor.
- No makeup test(s) will be given, and If you miss a test, you will receive zero credit. If you have an excused absence, please discuss it with the instructor ahead of time or as soon as it is feasible. Failure to take the final examination will result in an automatic "F" grade.
- The final exam is a comprehensive test but focuses on material not covered in the prior exams. The final exam will include questions from the laboratory part of the Course.
- All the class handouts for the whole class will be provided in eCourses at the first 3 weeks of the session.
- All homework will be assigned in eCourses, and the students should work on them independently and submit them in eCourses as per the deadlines. Any copying will result in zero credit. Standard 8½" X 11" paper should be used for homework [Engineering paper is recommended], and work should be submitted in eCourses as one PDF file for each assignment. Jpeg or other picture files of each page will not be accepted.
- Students must complete the design project (water and wastewater treatment plants for a selected city (will be assigned in class) as a group project(group will be selected in class) and submit before the deadline.

- Exams (format will be finalized shortly) will be conducted as scheduled (changes will be announced if needed) with the final exam scheduled during the final exam period)
- Any form of Dishonesty will result in a grade of F (ZERO) for the assignment or test involved (see University Policy below). It is student's responsibility to stay away from any appearance of cheating

**Calendar** (You should check university Calendar for the accuracy of dates)

|                                                      |               |
|------------------------------------------------------|---------------|
| ♦ Classes Start                                      | August 23     |
| ♦ Final day to drop without (W) Record               | September 7   |
| ♦ Mid-Semester Exam Period                           | October 14-16 |
| ♦ Final Day to Withdraw from classes with Record (W) | November 01   |
| ♦ Last day to withdraw from University (all courses) | December 01   |
| ♦ Final Exam: Per the university final exam calendar | December 2-8  |

**Policy to Eradicate Cheating (Protect Integrity of Exams)**

Cheating is unprofessional, unethical, and is antithetical to our core value of "Excellence in Civil Engineering Education" and WILL NOT BE TOLERATED at any level. To combat this serious problem, the Civil & Environmental Engineering (CEE) Department has adopted the following rules to eradicate cheating.

- If a student cheats on a test/assignment, the student shall receive an **automatic zero** for the test/assignment.
- A student who has been determined to have cheated in a course will IMMEDIATELY relinquish his/her leadership position in any of the department's professional organizations.
- If a student cheats multiple times in a course, the student will receive a **grade of "F"** for the Course.
- The calculators allowed for use in exams is **restricted** to the **latest** FE-approved calculators. For the latest NCEES FE approved calculators visit [ncees.org](https://ncees.org) or <https://ncees.org/exams/calculator/>  
[This NCEES policy protects the integrity of NCEES exams and has been adopted to do likewise for department's exams.]

| CVEG 4301: Environmental Engineering Design<br>16 WEEK CALENDAR |                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Week One: Topic</b><br><b>8/24 &amp; 8/26</b>                | Course Introduction<br>Introduction to Water and Wastewater Treatment ( <b>Module # 1</b> ) <ul style="list-style-type: none"> <li>• Design Parameters and Principles</li> <li>• Standards and Regulations</li> </ul>                                                                                                                                   |
| Chapter (s):                                                    | Chapter 1 and Chapter 4                                                                                                                                                                                                                                                                                                                                 |
| Assignment (s):                                                 | Discussion Assignment (DA) # 1-                                                                                                                                                                                                                                                                                                                         |
| <b>Week Two: Topic</b><br><b>8/31 &amp; 9/2</b>                 | Water and Wastewater Quantities ( <b>Module #2</b> )<br>Water Demand <ul style="list-style-type: none"> <li>• Water usage</li> <li>• Demand variability</li> </ul> Wastewater Generation                                                                                                                                                                |
| Chapter (s):                                                    | Handout#1 Water Quantity from Water Quality                                                                                                                                                                                                                                                                                                             |
| Assignment (s):                                                 | Homework (HW) # 1-                                                                                                                                                                                                                                                                                                                                      |
| <b>Week Three: Topic</b><br><b>9/7 &amp; 9/9</b>                | Water and Wastewater Treatment ( <b>Module # 3</b> )<br>Water Quality <ul style="list-style-type: none"> <li>• Physical, chemical and biological characteristics</li> <li>• Water Quality Standards</li> </ul> Overview of Treatment Methods for Water & Wastewater                                                                                     |
| Chapter (s):                                                    | Chapter 6 and 8 plus Handout from Chapter 11-Water Quality                                                                                                                                                                                                                                                                                              |
| Assignment (s):                                                 | HW # 2-                                                                                                                                                                                                                                                                                                                                                 |
| <b>Week Four: Topic</b><br><b>9/14 &amp; 9/16</b>               | Water Treatment –Coagulation & Flocculation ( <b>Module # 4</b> )<br>Coagulation <ul style="list-style-type: none"> <li>• Theory</li> <li>• Physical and Chemical aspects</li> <li>• pH and alkalinity</li> <li>• Mixing</li> </ul> Flocculation <ul style="list-style-type: none"> <li>• Theory</li> <li>• Mixing</li> <li>• Applications</li> </ul>   |
| Chapter (s):                                                    | Chapter 6 and 8 plus Handout from Chapter 11                                                                                                                                                                                                                                                                                                            |
| Assignment (s):                                                 | DA # 2-<br>HW # 3-                                                                                                                                                                                                                                                                                                                                      |
| <b>Week Five: Topic</b><br><b>9/21 &amp; 9/23</b>               | Water Treatment – Softening ( <b>Module # 5</b> )<br>Softening <ul style="list-style-type: none"> <li>• Lime-Soda softening</li> <li>• Chemical dosage</li> <li>• Design</li> </ul>                                                                                                                                                                     |
| Chapter (s):                                                    | Chapter 6 and Handout                                                                                                                                                                                                                                                                                                                                   |
| Assignment (s):                                                 | DA # 3 (preparation for Exam # 1)<br><b>Exam # 1 –</b>                                                                                                                                                                                                                                                                                                  |
| <b>Week Six: Topic</b><br><b>9/28 &amp; 9/30</b>                | Water Treatment – Softening ( <b>Module # 5</b> )...continued<br>Softening <ul style="list-style-type: none"> <li>• Design</li> <li>• Mixing</li> <li>• Ion Exchange</li> </ul> Water Treatment -Sedimentation ( <b>Module # 6</b> )<br>Sedimentation <ul style="list-style-type: none"> <li>• Types of sedimentation</li> <li>• Stoke's law</li> </ul> |
| Chapter (s):                                                    | Chapter 6 and Handout                                                                                                                                                                                                                                                                                                                                   |

|                                                                 |                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Assignment (s):                                                 | HW # 4 – Due Date:                                                                                                                                                                                                                                                             |
| <b>Week Seven:</b> Topic<br><b>10/5 &amp; 10/7</b>              | Water Treatment -Sedimentation ( <b>Module # 6</b> )<br>Sedimentation <ul style="list-style-type: none"> <li>• Design of sedimentation basins for Water &amp; Wastewater</li> <li>• Different Configurations</li> </ul>                                                        |
| Chapter (s):                                                    | Chapter 6, Handout                                                                                                                                                                                                                                                             |
| Assignment (s):                                                 | HW # 5 -                                                                                                                                                                                                                                                                       |
| <b>Week Eight:</b> Topic<br><b>10/12 &amp; 10/14</b>            | Chapter 6- Filtration ( <b>Module # 7</b> )<br>Filtration <ul style="list-style-type: none"> <li>• Filter media; grain size distribution</li> <li>• Mechanisms of filtration</li> <li>• Head loss</li> <li>• Backwashing</li> <li>• Flow apportionment</li> </ul>              |
| Chapter (s):                                                    | Chapter 6, Handout<br><b>Mid-Term –</b>                                                                                                                                                                                                                                        |
| Assignment (s):                                                 | HW # 6-<br>DA # 4: Water Treatment Plant- Design Project –                                                                                                                                                                                                                     |
| <b>Week Eight:</b> Topic<br><b>10/19 &amp; 10/21</b>            | Water Treatment – Disinfection ( <b>Module #8</b> )<br>Disinfection <ul style="list-style-type: none"> <li>• Chemistry</li> <li>• Mechanisms of disinfection</li> <li>• Disinfection kinetics</li> <li>• By-products</li> </ul>                                                |
| Chapter (s):                                                    | Chapter 6, Handout                                                                                                                                                                                                                                                             |
| Assignment (s):                                                 | DA # 5                                                                                                                                                                                                                                                                         |
| <b>Week Nine:</b> Topic<br><b>10/26 &amp; 10/28</b>             | Wastewater Collection and Treatment ( <b>Module #9</b> ) <ul style="list-style-type: none"> <li>• Sources and flow rates</li> <li>• Characteristics; COD, BOD</li> <li>• Treatment standards</li> <li>• Disposal regulations</li> </ul>                                        |
| Chapter (s):                                                    | Chapter 8 and Handout                                                                                                                                                                                                                                                          |
| Assignment (s):                                                 | HW# 7-                                                                                                                                                                                                                                                                         |
| <b>Week Ten:</b> Topic<br><b>11/2 &amp; 11/4</b>                | Wastewater Characteristics ( <b>Module # 10</b> ) <ul style="list-style-type: none"> <li>• Micro-organisms</li> <li>• Aerobic and anaerobic decomposition</li> <li>• Bacterial growth</li> <li>• Application in wastewater treatment</li> </ul>                                |
| Chapter (s):                                                    | Chapter 8, Handout                                                                                                                                                                                                                                                             |
| Assignment (s):                                                 | HW # 8 –                                                                                                                                                                                                                                                                       |
| <b>Week Eleven:</b><br><b>Topic</b><br><b>11/9 &amp; 11/11</b>  | Wastewater Treatment –Primary & Secondary Treatment ( <b>Module #11</b> )<br>Pretreatment<br>Primary Treatment <ul style="list-style-type: none"> <li>• Primary Clarifier</li> </ul> Secondary Treatment <ul style="list-style-type: none"> <li>• Trickling filters</li> </ul> |
|                                                                 | Chapter 8, Handout                                                                                                                                                                                                                                                             |
| Assignment (s):                                                 | <b>Exam # 3 –</b>                                                                                                                                                                                                                                                              |
| <b>Week Twelve:</b><br><b>Topic</b><br><b>11/16 &amp; 11/18</b> | Wastewater Treatment –Primary & Secondary Treatment ( <b>Module #11</b> )<br>Secondary Treatment <ul style="list-style-type: none"> <li>• Activated sludge</li> <li>• Secondary Clarifier</li> </ul>                                                                           |
| Chapter (s):                                                    | Chapter 8, Handout                                                                                                                                                                                                                                                             |
| Assignment (s):                                                 | HW #9-                                                                                                                                                                                                                                                                         |

|                                                       |                                                                                                                                                                                                  |
|-------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Week Thirteen:</b><br><b>Topic</b><br><b>11/23</b> | Wastewater Treatment -Sludge treatment ( <b>Module #12</b> )<br>Sludge treatment <ul style="list-style-type: none"> <li>• Thickening, stabilization, conditioning</li> <li>• Disposal</li> </ul> |
| Chapter (s):                                          | Chapter 8, Handout                                                                                                                                                                               |
| Assignment (s):                                       | DA # 6: Project Deliverables –                                                                                                                                                                   |
| <b>Week Fourteen:</b><br><b>Topic</b><br><b>11/30</b> | Wastewater Treatment -Tertiary treatment ( <b>Module #13</b> )<br>Advanced Treatment processes                                                                                                   |
| Chapter (s):                                          | Handout                                                                                                                                                                                          |
| Assignment (s):                                       | <b>Design Project – Due Date: December 1, 2021</b>                                                                                                                                               |
| <b>Final Week</b>                                     | <b>Final Exam – Will be Announced per university final exam schedule</b>                                                                                                                         |

**Civil Engineering Program Outcomes (Student Learning Outcomes)**  
**ABET EAC Criterion 3 {[1] - [7]} Student Outcomes (SOs)**

- 1) an ability to identify, formulate, and solve **complex** engineering problems by applying principles of engineering, science, and mathematics
- 2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- 3) an ability to communicate effectively with a range of audiences
- 4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- 5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- 6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- 7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

**Civil Engineering Program Criteria**

**Curriculum:** The curriculum must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, **and at least one additional area of basic science; apply probability and statistics to address uncertainty; analyze and solve problems in at least four technical areas appropriate to civil engineering; conduct experiments in at least two technical areas of civil engineering and analyze and interpret the resulting data; design a system, component, or process in at least two civil engineering contexts; include principles of sustainability in design; explain basic concepts in project management, business, public policy, and leadership; analyze issues in professional ethics; and explain the importance of professional licensure.**

**Faculty:** The program must demonstrate that faculty teaching courses that are primarily design in content are **qualified to teach the subject matter by virtue of professional licensure, or by education and design experience.** The program must demonstrate that it is **not critically dependent on one individual.**

**Civil Engineering Program Educational Objectives (PEOs)**

Graduates from the Civil Engineering program will:

1. Have careers in civil engineering or related fields that lead to increasing levels of responsibility and leadership
2. Obtain professional licensure/certifications
3. Complete graduate studies in civil engineering or related fields
4. Engage in professional development and service

**Mapping of Program Educational Objectives onto Student Outcomes**

| PEO          | Program Educational Objectives                                                                                      | CE Student Outcomes |            |            |            |            |            |            |
|--------------|---------------------------------------------------------------------------------------------------------------------|---------------------|------------|------------|------------|------------|------------|------------|
|              | <i>Graduates from the Civil Engineering program will:</i>                                                           | <b>[1]</b>          | <b>[2]</b> | <b>[3]</b> | <b>[4]</b> | <b>[5]</b> | <b>[6]</b> | <b>[7]</b> |
| <b>PEO 1</b> | Have careers in civil engineering or related fields that lead to increasing levels of responsibility and leadership | X                   | X          | X          | X          | X          | X          | X          |
| <b>PEO 2</b> | Obtain professional licensure/certifications                                                                        | X                   | X          |            |            |            |            |            |
| <b>PEO 3</b> | Complete graduate studies in civil engineering or related fields                                                    | X                   | X          | X          | X          |            | X          | X          |
| <b>PEO 4</b> | Engage in professional development and service                                                                      | X                   | X          | X          | X          |            | X          | X          |

## Mapping of CE Courses and Student Outcomes [Beginning Fall 2019] Updated Fall 2021

| Previous Course No. | New Course No. | Course Title                          | CE Student Outcomes/SOs |     |     |     |     |     |     |
|---------------------|----------------|---------------------------------------|-------------------------|-----|-----|-----|-----|-----|-----|
|                     |                |                                       | [1]                     | [2] | [3] | [4] | [5] | [6] | [7] |
| CVEG 1011           | CVEG 1101      | Introduction to Engineering           |                         |     |     |     |     |     |     |
| CVEG 1021           | CVEG 1102      | Introduction to Civil Engineering Lab |                         |     |     |     |     |     | I   |
| CVEG 2043           | CVEG 2301      | Engineering Mechanics I               |                         |     |     |     |     |     | I   |
| CVEG 2061           | CVEG 2101      | Materials & Dynamics Lab              |                         |     |     |     |     | I   |     |
| CVEG 2063           | CVEG 2332      | Mechanics of Materials I              |                         | I   |     |     |     |     |     |
| CVEG 2073           | CVEG 2304      | Global Development Issues {CORE}      |                         |     | I   | √   | I   |     | R   |
| CVEG 2081           | CVEG 2102      | Surveying & Geospatial Concepts       |                         |     | R   |     |     | I   |     |
| CVEG 3023           | CVEG 3300      | Geotechnical Engineering              |                         | I   |     |     |     |     |     |
| CVEG 3031           | CVEG 3100      | Concrete & Steel Lab                  |                         |     |     |     |     | √   |     |
| CVEG 3043           | CVEG 3301      | Environmental Engineering             |                         |     | R   |     |     | √   |     |
| CVEG 3051           | CVEG 3102      | Professional Engineering I            |                         |     |     | √   |     |     |     |
| CVEG 3053           | CVEG 3302      | Transportation Engineering            |                         |     | R   |     | √   |     |     |
| CVEG 3063           | CVEG 3303      | Hydraulics                            |                         |     | √   |     | R   | √   |     |
| CVEG 3073           | CVEG 3304      | Structural Analysis I                 | I                       |     |     |     |     |     | √   |
| CVEG 3083           | CVEG 3305      | Steel Design                          | √                       | √   | R   |     |     |     |     |
| CVEG 4013           | CVEG 4300      | Reinforced Concrete                   | R                       | √   |     |     |     |     |     |
| CVEG 4021           | CVEG 4100      | Geotech Engineering Design Lab        |                         | R   |     |     |     |     | √   |
| CVEG 4043           | CVEG 4301      | Environmental Engineering Design      | √                       | √   | R   |     |     |     |     |
| CVEG 4053           | CVEG 4302      | Transportation Engineering Design     | √                       |     |     |     | √   |     |     |
| CVEG 4063           | CVEG 4303      | Water Resources Engineering           | √                       | √   |     |     |     |     | I   |
| CVEG 4093           | CVEG 4304      | Systems Engineering                   |                         | √   |     |     |     |     | √   |
| CVEG 4472           | CVEG 4200      | Sr. Design & Professionalism I        |                         | √   | √   | √   | √   |     | √   |
| CVEG 4482           | CVEG 4201      | Sr. Design & Professionalism II       | √                       | √   | √   | √   |     |     |     |

I – means the described outcome is introduced (not measured) but could be monitored.

√ - means that the skills described in the program outcome are covered and **measured** in the Course.

R – means the described outcome is reinforced in the Course (not measured) but could be monitored.

**Additionally**, evidence is to be collected to satisfy **CE Program Criteria** covering basic concepts in **Management** (CVEG 3302, 4302, 4200, 4201, 4304), **Business** (CVEG 4304, 4200, 4201), **Public Policy** (CVEG 2304, 4200, 4201), **Professional Ethics** (CVEG 1102, 2304, 3102), **Leadership** (CVEG 4200, 4201), **Consideration of Sustainability** (CVEG 4301, 4302, 4303), **Importance of Professional Licensure** (CVEG 3102, 4200, 4201).

### The Assessment Process

Student Learning outcomes are measured using both **direct** and **indirect** measurements. Direct measurements are derived from either designated homework, tests, lab reports, project reports or other assignments. Indirect measurements are drawn from end-of-semester Student Opinion Surveys (SOS) and any surveys completed by graduating Seniors. The above-listed Student Learning Outcomes (Program Outcomes) are measured and evaluated in specified cycles, and an Assessment Report is prepared annually for the purposes of continuously improving the Program's learning outcomes.

## **Student Support and Success**

### **John B. Coleman Library**

The John B. Coleman Library's mission is to enhance the scholarly pursuit of knowledge, to foster intellectual curiosity, and to promote life-long learning and research through our innovative services, resources, and cultural programs, which support the Prairie View A&M University's global mission of teaching, service, and research. It maintains library collections and access both on campus, online, and through local agreements to further the educational goals of students and faculty. Website: <https://www.pvamu.edu/library/>; Phone: 936-261-1500

### **Academic Advising Services**

Academic Advising Services offers students a variety of services that contributes to student success and leads towards graduation. We assist students with understanding university policies and procedures that affect academic progress. We support the early alert program to help students get connected to success early in the semester. We help refer students to the appropriate academic support services when they are unsure of the best resource for their needs. Faculty advisors support some students in their respective colleges. Your faculty advisor can be identified in PantherTracks. Advisors with Academic Advising Services are available to all students. We are located across campus. Find your advisor's location by academic major at [www.pvamu.edu/advising](http://www.pvamu.edu/advising). Phone: 936-261-5911

### **The University Tutoring Center**

The University Tutoring Center (UTC) offers free tutoring and academic support to all registered PVAMU students. The mission of the UTC is to help provide a solid academic foundation that enables students to become confident, capable, independent learners. Competent and caring staff and peer tutors guide students in identifying, acquiring, and enhancing the knowledge, skills, and attitudes needed to reach their desired goals. Tutoring and academic support are offered face-to-face in the UTC, in virtual face-to-face sessions (<https://www.pvamu.edu/student-success/sass/university-tutoring-center/>), and through online sessions (<https://www.pvamu.edu/pvplace/>). Other support services available for students include Supplemental Instruction, Study Break, Academic Success Workshops, and Algebra Study Jam. Location: J. B. Coleman Library, Rm. 307; Phone: 936-261-1561; Email: [pv tutoring@pvamu.edu](mailto:pv tutoring@pvamu.edu); Website: <https://www.pvamu.edu/student-success/sass/university-tutoring-center/>

### **Writing Center**

The Writing Center provides well-trained peer tutors to assist students with writing assignments at any stage of the writing process. Tutors help students with various writing tasks from understanding assignments, brainstorming, drafting, revising, editing, researching, and integrating sources. Students have free access to Grammarly online writing assistance. Grammarly is an automated proofreading and plagiarism detection tool. Students must register for Grammarly by using their student email address. In addition, students have access to face-to-face and virtual tutoring services either asynchronously via email or synchronously via Zoom. Location: J. B. Coleman Library, Rm. 209; Phone: 936-261-3724; Website: <https://www.pvamu.edu/student-success/writing-center/>; Grammarly Registration: <https://www.grammarly.com/enterprise/signup>

### **Academic Early Alert**

Academic Early Alert is a proactive system of communication and collaboration between faculty, academic advisors, and PVAMU students that is designed to support student success by promptly identifying issues and allowing for intervention. Academic Early Alerts help students by providing a central location to schedule advising appointments, view advisor contact information, and request assistance. Students who recognize that they have a problem that is negatively affecting their academic performance or ability to continue school may self-refer an Academic Early Alert. To do so, students will log in to PV Place and click on Academic Early Alert on the left sidebar. Phone: 936-261-5902; Website: <https://www.pvamu.edu/student-success/early-alert/>

### **Student Counseling Services**

The Student Counseling Services unit offers a range of services and programs to assist students in maximizing their potential for success: short-term individual, couples, and group counseling, as well as crisis intervention, outreach, consultation, and referral services. The staff is licensed by the State of Texas and assists students who are dealing with academic skills concerns, situational crises, adjustment problems, and emotional difficulties. Information shared with the staff is treated confidentially and in accordance with Texas State Law. Location: Hobart Taylor, 2<sup>nd</sup> floor; Phone: 936-261-3564; Website: <https://www.pvamu.edu/healthservices/student-counseling-services/>

### **Office of Testing Services**

Testing Services serves to create opportunities by offering a suite of exams that aid in the students' academic and professional success. Currently, we administer entrance (HESI A2), college readiness (TSI assessment), Prior Learning (CLEP, DSST), and proctored exams. Location: Wilhelmina Delco, 3<sup>rd</sup> Floor, Rm. 305; Phone: 936-261-3627; Email: [aetesting@pvamu.edu](mailto:aetesting@pvamu.edu); Website: [www.pvamu.edu/testing](http://www.pvamu.edu/testing)

### **Office of Diagnostic Testing and Disability Services**

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, contact the Office of Disability Services. As a federally-mandated educational support unit, the Office of Disability Services serves as the repository for confidential disability files for faculty, staff, and students. For persons with a disability, the Office develops individualized ADA letters of request for accommodations. Other services include learning style inventories, awareness workshops, accessibility pathways, webinars, computer laboratory with adapted hard and software, adapted furniture, proctoring non-standardized test administrations, ASL interpreters, ALDs, digital recorders, Livescribe, and a comprehensive referral network across campus and the broader community. Location: Hobart Taylor, Rm. 1D128; Phone: 936-261-3583; Website: <https://www.pvamu.edu/disabilityservices/>

### **Center for Instructional Innovation and Technology Services (CIITS)**

Distance Learning, also referred to as Distance Education, is the employment of alternative instructional delivery methods to extend programs and services to persons unable to attend college in the traditional manner. The Center for Instructional Innovation and Technology Services (CIITS) supports student learning through online, hybrid, web-assist, and 2-way video course delivery. For more details and contact information, visit: <https://www.pvamu.edu/dlearning/distance-learning-2-2/students-2/>; Phone: 936-261-3283

### **Veteran Affairs**

Veterans Services works with student veterans, current military and military dependents to support their transition to the college environment and continued persistence to graduation. The Office coordinates and certifies benefits for both the G.I. Bill and the Texas Hazlewood Act. Location: Evans Hall, Rm. 102; Phone: 936-261-3563; Website: <https://www.pvamu.edu/sa/departments/veteranaffairs/>

### **Office for Student Engagement**

The Office for Student Engagement delivers comprehensive programs and services designed to meet the co-curricular needs of students. The Office implements inclusive and accessible programs and services that enhance student development through exposure to and participation in diverse and relevant social, cultural, intellectual, recreational, community service, leadership development, and campus governance. Location: Memorial Student Center, Rm. 221; Phone: 936-261-1340; Website: <https://www.pvamu.edu/studentengagement/>

### **Career Services**

Career Services supports students through professional development, career readiness, and placement and employment assistance. The Office provides one-on-one career coaching, interview preparation, resume and letter writing, and career exploration workshops and seminars. Services are provided for students at the Northwest Houston Center and College of Nursing in the Medical Center twice a month or on a requested basis. Distance Learning students are encouraged to visit the Career Services website for information regarding services provided. Location: Anderson Hall, 2<sup>nd</sup> floor; Phone: 936-261-3570; Website: <https://www.pvamu.edu/careerservices/>

## **University Rules and Procedures**

### **Academic Misconduct**

Academic dishonesty is defined as any form of cheating or dishonesty that has the effect or intent of interfering with any academic exercise or fair evaluation of a student's performance. The college faculty can provide additional information, particularly related to a specific course, laboratory, or assignment.

You are expected to practice academic honesty in every aspect of this Course and all other courses. Make sure you are familiar with the *University Administrative Guidelines on Academic Integrity*, which can be found on the [Academic Integrity webpage](#). Students who engage in academic misconduct are subject to university disciplinary procedures. As listed in the *University Administrative Guidelines on Academic Integrity*, the University Online Catalog, and the

Student Code of Conduct, the following are examples of prohibited conduct. This list is not designed to be all-inclusive or exhaustive. In addition to academic sanctions, any student found to have committed academic misconduct that is also a violation of criminal law may also be subject to disciplinary review and action by the Office of Student Conduct (as outlined in the Student Code of Conduct).

### **Forms of Academic Dishonesty:**

1. Cheating: Deception in which a student misrepresents that he/she has mastered information on an academic exercise that he/she has not learned, giving or receiving aid unauthorized by the instructor on assignments or examinations. Examples: unauthorized use of notes for a test; using a "cheat sheet" on a quiz or exam; any alteration made on a graded test or exam which is then resubmitted to the teacher;
2. Plagiarism: Careless or deliberate use of the work or the ideas of another; representation of another's work, words, ideas, or data as your own without permission or appropriate acknowledgment. Examples: copying another's paper or answers, failure to identify information or essays from the internet and submitting or representing it as your own; submitting an assignment which has been partially or wholly done by another and claiming it as yours; not properly acknowledging a source which has been summarized or paraphrased in your work; failure to acknowledge the use of another's words with quotation marks;
3. Collusion: When more than one student or person contributes to a piece of work that is submitted as the work of an individual;
4. Conspiracy: Agreeing with one or more persons to commit an act of academic/scholastic dishonesty; and
5. Multiple Submission: Submission of work from one Course to satisfy a requirement in another course without explicit permission. Example: using a paper prepared and graded for credit in one Course to fulfill a requirement and receive credit in a different course.

### **Nonacademic Misconduct**

The university respects the rights of instructors to teach and students to learn. Maintenance of these rights requires campus conditions that do not impede their exercise. Campus behavior that interferes with either (1) the instructor's ability to conduct the class, (2) the inability of other students to profit from the instructional program, or (3) campus behavior that interferes with the rights of others will not be tolerated. An individual engaging in such disruptive behavior may be subject to disciplinary action. The Office of Student Conduct will adjudicate such incidents under nonacademic procedures.

### **Sexual Misconduct**

Sexual harassment of students and employees at Prairie View A&M University is unacceptable and will not be tolerated. Any member of the university community violating the university's sexual harassment policy will be subject to disciplinary action. In accordance with the Texas A&M University System guidelines, your instructor is obligated to report to the Office of Title IX Compliance ([titleixteam@pvamu.edu](mailto:titleixteam@pvamu.edu)) any instance of sexual misconduct involving a student, which includes sexual assault, stalking, dating violence, domestic violence, and sexual harassment, about which the instructor becomes aware during this Course through writing, discussion, or personal disclosure. The faculty and staff of PVAMU actively strive to provide a learning, working, and living environment that promotes respect that is free from sexual misconduct, discrimination, and all forms of violence. If students, faculty, or staff would like assistance or have questions, they may contact the Title IX Coordinator at 936-261-2144 or [titleixteam@pvamu.edu](mailto:titleixteam@pvamu.edu). More information can be found at [www.pvamu.edu/titleix](http://www.pvamu.edu/titleix), including confidential resources available on campus.

### **Pregnancy, Pregnancy-related, and Parenting Accommodations**

Title IX of the Education Amendments of 1972 prohibits sex discrimination, which includes discrimination based on pregnancy, marital status, or parental status. Students seeking accommodations related to pregnancy, pregnancy-related conditions, or parenting (reasonably immediate postpartum period) are encouraged to contact Student Disability Services or the Dean of Students' Office for additional information and to request accommodations.

### **Non-Discrimination Statement**

Prairie View A&M University does not discriminate on the basis of race, color, sex, religion, national origin, age, disability, genetic information, veteran status, sexual orientation, or gender identity in its programs and activities. The

University is committed to supporting students and complying with The Texas A&M University System non-discrimination policy. It seeks to establish an environment that is free of bias, discrimination, and harassment. If you experience an incident of discrimination or harassment, we encourage you to report it. If you would like to speak with someone who may be able to afford you privacy or confidentiality, there are individuals who can meet with you. The Director of Equal Opportunity & Diversity has been designated to handle inquiries regarding the non-discrimination policies and can be reached at Harrington Science Building, Suite 109 or by phone at 936-261-1744 or 1792.

### **Class Attendance Policy (See the University Online Catalog for Full Attendance Policy)**

Prairie View A&M University requires regular class attendance. Attending all classes supports the full academic development of each learner, whether classes are taught with the instructor physically present or via distance learning technologies such as interactive video and/or the internet. Excessive absenteeism, whether excused or unexcused, may result in a student's course grade being reduced or in the assignment of a grade of "F." Absences are accumulated beginning with the first day of class during regular semesters and summer terms. Each faculty member will include the University's attendance policy in each course syllabus.

### **Student Academic Appeals Process**

Authority and responsibility for assigning grades to students rest with the faculty. However, in those instances where students believe that miscommunication, errors, or unfairness of any kind may have adversely affected the instructor's assessment of their academic performance, the student has a right to appeal by the procedure listed in the University Online Catalog and by doing so within thirty days of receiving the grade or experiencing any other problematic academic event that prompted the complaint.

### **Technical Considerations**

#### **Minimum Recommended Hardware and Software:**

- Intel PC or Laptop with Windows 10 or later version; Mac with OS High Sierra\*
- Smartphone or iPad/Tablet with Wi-Fi\*
- High-speed Internet access
- 8 GB Memory
- Hard drive with 320 GB storage space
- 15" monitor, 800x600, color or 16 bit
- Sound card w/speakers
- Microphone and recording software
- Keyboard & mouse
- Most current version of Google Chrome, Safari, or Firefox

**Note:** Be sure to enable Java & pop-ups in the Web browser preferences

\* Smartphones, Google Chrome books, and Android tablets may not be supported. iPads are the only tablets supported.

#### **Participants should have a basic proficiency of the following computer skills:**

- Sending and receiving email
- A working knowledge of the Internet
- Microsoft Word (or a program convertible to Word)
- Acrobat PDF Reader
- Windows or Mac OS
- Video conferencing software

#### **Netiquette (online etiquette)**

Students are expected to participate in all discussions and virtual classroom chats as directed. Students are to be respectful and courteous to others on discussion boards. Foul or abusive language will not be tolerated. Do not use ALL CAPS for communicating to others AS IT CAN BE INTERPRETED AS YELLING. Avoid slang terms such as "wassup?" and texting abbreviations such as "u" instead of "you." Limit and possibly avoid the use of emoticons. Be cautious when using humor or sarcasm as tone is sometimes lost in an email or discussion post, and the message might be taken seriously or sound offensive.

### **Video Conferencing Etiquette**

When using Zoom, WebEx, or other video conferencing tools, confirm the visible area is tidy, clear of background clutter, inappropriate or offensive posters, and other distractions. Ensure you dress appropriately and avoid using high traffic or noisy areas. Stay muted when you are not speaking and avoid eating/drinking during the session. Before the class session begins, test audio, video, and lighting to alleviate technology issues.

### **Technical Support**

Students should go to <https://mypassword.pvamu.edu/> if they have password issues. The page will provide instructions for resetting passwords and contact information if login issues persist. For other technical questions regarding eCourses, call the Center for Instructional Innovation and Technology Services at 936-261-3283 or email ciits@pvamu.edu.

### **Communication Expectations and Standards**

Emails or discussion postings will receive a response from the instructor, usually in less than 48 hours. Urgent emails should be marked as such. Check regularly for responses.

### **Discussion Requirement**

Online courses often require minimal to no face-to-face meetings. However, conversations about the readings, lectures, materials, and other aspects of the Course can occur in a seminar fashion. The use of the discussion board will accomplish this. The instructor will determine the exact use of discussion boards.

**It is strongly suggested** that students type their discussion postings in a word processing application such as Word and save it to their PC or a removable drive before posting to the discussion board. This is important for two reasons: 1) If for some reason your discussion responses are lost in your online Course, you will have another copy; 2) Grammatical errors can be greatly minimized by the use of the spell-and-grammar check functions in word processing applications. Once the post(s) have been typed and corrected in the word processing application, copy and paste to the discussion board.

### **COVID-19 Campus Safety Measures**

To promote public safety and protect students, faculty, and staff during the coronavirus pandemic, PVAMU has adopted policies and practices to limit virus transmission.

- **Self-monitoring** - Students should follow CDC recommendations for self-monitoring. Students who have a fever or exhibit symptoms of COVID-19 should participate in class remotely and should not participate in face-to-face instruction.
- **Face Coverings** - Face coverings (cloth face covering, surgical mask, etc.) are recommended in classrooms, teaching laboratories, common spaces such as lobbies and hallways, public study spaces, libraries, academic resource, and support offices, and outdoor spaces where 6 feet of physical distancing is challenging to maintain reliably.
- **Physical Distancing** - Physical distancing should be maintained between students, instructors, and others in Course and course-related activities where possible.

**Personal Illness and Quarantine** - Students required to quarantine are to participate in courses and course-related activities remotely and must not attend face-to-face course activities. Students should notify their instructors of the quarantine requirement. Students under quarantine are expected to participate in courses and complete graded work unless they have symptoms that are too severe to participate in course activities. Students experiencing personal injury or illness that is too severe for the student to attend class qualify for an excused absence. To receive an excused absence, students must provide appropriate documentation to the Office for Student Conduct, studentconduct@pvamu.edu

|    |                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | <b>Course number and name:</b>                                                                                                                                                                                             | CVEG 4301 Environmental Engineering Design                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 2. | <b>Credits and contact hours:</b>                                                                                                                                                                                          | 3 credit hours; 3 contact hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 3. | <b>Instructor's or course coordinator's name:</b>                                                                                                                                                                          | Dr. Raghava R. Kommalapati, PE, BCEE, F. ASCE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4. | <b>Text book: Title:</b>                                                                                                                                                                                                   | Introduction to Environmental Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|    | Author:                                                                                                                                                                                                                    | Davis & Cornwell,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|    | Publisher, Year & Edition:                                                                                                                                                                                                 | McGraw-Hill, 2013 5 <sup>th</sup> ed.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|    | a. Other Supplemental material                                                                                                                                                                                             | 1. Water and Wastewater Engineering: Design Principles and Practice, 2 <sup>nd</sup> ed., Davis, McGraw Hill, 2020, ISBN 978-1-260-13227-4<br>2. Water Quality, Tchobanoglous and Schroeder, Addison-Wesley, 1985<br>3. Water Treatment Principles and Design, 3rd ed., MWH, Crittenden, Trussell, Hand, Howe and Tchobanoglous 2012, John-Wiley & Sons<br>4. Water and Wastewater Technology, 6th ed, Hammer and Hammer, 2008, Prentice Hall.<br>5. Water Supply and Pollution Control, 8th ed, Viesman, Hammer Perez and Chadik, 2009, Prentice Hall.<br>6. Water Treatment Unit Processes: Physical and Chemical, Hendricks, 2006, CRC Press.<br>7. Wastewater Engineering, 5th edition, Metcalf and Eddy, 2014, McGraw-Hill |
| 5. | <b>Specific course information</b>                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|    | a. Brief description of the content of the course (catalog description)                                                                                                                                                    | CVEG 4301 (3-0) Credit 3 semester hours. Synthesis of environmental engineering fundamentals into an integrated system design which includes the design of physical, chemical, and biological unit operations and processes in water and wastewater treatment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|    | b. Prerequisites or Co-requisites                                                                                                                                                                                          | CVEG 3043: Environmental Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|    | c. *Indicate whether a required, elective, or selected elective (as per definition provided) course in the program                                                                                                         | Required                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 6. | a. <b>Specific goals for the course specific outcomes of instruction</b> (e.g. The student will be able to explain the significance of current research about a particular topic.)<br><br><i>Students will be able to:</i> | b. <b>Explicitly indicate which of the student outcomes listed in Criterion 3</b> or any other outcomes are addressed by the course.<br><br><i>The specific goals for the course specific outcomes listed on the left column will address the following student learning outcomes:</i>                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|    | 1. Comprehend the fundamentals of environmental engineering                                                                                                                                                                | <b>Outcome 1</b><br>An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|    | 2. Determine the water requirements for a municipality or water district                                                                                                                                                   | <b>Outcome 1</b><br>An ability to identify, formulate, and solve complex                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

|    |                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | 3. Determine the waste volumes from a development or a municipality          | engineering problems by applying principles of engineering, science, and mathematics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|    | 4. design physical and chemical treatment methods for water                  | <b>Outcome 2</b><br>an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors                                                                                                                                                                                                                                                                                                                                                                                                     |
|    | 5. design physical, chemical and biological treatment methods for wastewater |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|    | 6. understand contemporary issues related to water/ wastewater treatment     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|    | 7. Research and complete a design project                                    | <b>Outcome 1</b><br>An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.<br><b>Outcome 2</b><br>an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors                                                                                                                                                                                                                                   |
| 7. | <b>Brief list of topics to be covered</b>                                    | Review of Environmental Engineering Design<br>Fundamentals (3 hours)<br>Water and Wastewater Quantities (3 hours)<br>Introduction to Water and Wastewater Treatment (3 hours)<br>Water Treatment Processes and Design (18 hours)<br>Coagulation & Flocculation<br>Softening (Lime and Soda and Ion Exchange)<br>Mixing<br>Sedimentation<br>Filtration<br>Disinfection<br>Other Methods<br>Wastewater Treatment Processes and Design (9 hours)<br>Primary Treatment<br>Secondary Treatment (Biological Treatment and Secondary Clarifier)<br>Disinfection<br>Sludge Management<br>Advanced Processes for Water and Wastewater Treatment (3 hours) |



PRAIRIE VIEW A&M UNIVERSITY

A Member of the Texas A&M University System

## **CVEG 4301– Environmental Engineering Design Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

### **End of Semester Course Assessment Report**

#### **1. Performance Statistics**

- Total number of students in class
- The class average performance (stated as %) in each course outcome assessed in this class and the two previous times course was assessed.
- The acceptable class average for the class in each outcome area as set by the Department.
- Percentage of students who scored below the expected average in each outcome.

#### **2. Implementation Summary**

- Brief summary of plans implemented during the semester based on last assessment report

#### **3. Perceived Problems**

- Instructor's critical evaluation of perceived problems that affected students' performance.

#### **4. New Plans for Addressing Problems**

- Instructor's plans for addressing the perceived problems the next time the class is taught.

#### **5. Overall Trend over last three assessment periods**

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

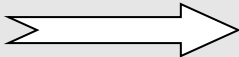
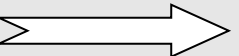
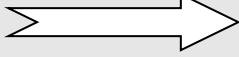
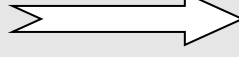
#### **6. Were Expectations Met?**

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer **NO**.

**END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT**  
**CVEG 4301: ENVIRONMENTAL ENGINEERING DESIGN**  
**FALL 2021 SEMESTER**

Report Prepared by: Raghava R. Kommalapati, Ph.D., PE, BCEE, F. ASCE

Report Date: December 14, 2021

| Semester                             | Analysis Type                                                                       | Number of Students | <b>Outcome (1)*</b><br>an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics                                                                               |                 |                              | <b>Outcome (2)**</b><br>an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors                 |               |                              |
|--------------------------------------|-------------------------------------------------------------------------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------------------------------|
|                                      |                                                                                     |                    | Expected Average %                                                                                                                                                                                                                             | Class Average % | % Students above Exp Average | Expected Average                                                                                                                                                                                                                                                 | Class Average | % Students above Exp Average |
| Fall 2020                            | Direct                                                                              | 16                 | 70                                                                                                                                                                                                                                             | 76.1            | 87.5                         | 70                                                                                                                                                                                                                                                               | 82.4          | 94                           |
| Fall 2020                            | Direct                                                                              | 17                 | 70                                                                                                                                                                                                                                             | 78.7            | 94                           | 70                                                                                                                                                                                                                                                               | 86.8          | 100                          |
| Fall 2019                            | Direct                                                                              | 23                 | 70                                                                                                                                                                                                                                             | 79.5            | 100                          | 70                                                                                                                                                                                                                                                               | 87.5          | 100                          |
| Fall 2018*                           | Direct                                                                              | 19                 |                                                                                                                                                                                                                                                |                 |                              | 70                                                                                                                                                                                                                                                               | 81.1          | 92.3                         |
| <b>Implementation Summary</b>        |    |                    | This outcome is measured from Fall 2019. Emphasized the analysis of the problem and brainstorming different ideas before selecting specific solutions for the problem. Held virtual problem-solving sessions outside class times.              |                 |                              | Continued providing students more example design problems and sample PE exam problems. The design project was assigned earlier and discussed design problems and provided feedback after the initial report.                                                     |               |                              |
| <b>Perceived Problems</b>            |    |                    | Performance is stable in this outcome. Students continue to exhibit a lack of ability to comprehend the given problem, break it down into manageable modules identify variables, and solve. They seem to lose it when problem-wording changes. |                 |                              | Performance is good. However, students seem to fail to understand the realistic designs. The students do not seem to understand what is practical and what is not. Several groups used the wrong alumna, and the number of sedimentation units is not practical. |               |                              |
| <b>Plans for Addressing Problems</b> |  |                    | Conduct problem-solving sessions from the beginning of the semester and emphasize skills that students should have learned in lower-level classes. Conduct assessment in the beginning and fix issues early in the semester.                   |                 |                              | Discuss the design problem and go over the design of each treatment unit as we finish the topic in the class. Give more practical examples and provide design reports for real-world projects.                                                                   |               |                              |
| <b>Overall Trend over Periods</b>    |  |                    | The average for this semester exceeds the Department expected average. And it is in the similar range as previous two semesters though it showed a slight decline.                                                                             |                 |                              | The average is above the expected department average. However, it declined from the previous two offerings.                                                                                                                                                      |               |                              |
| <b>Were expectations met?</b>        |                                                                                     |                    | Yes                                                                                                                                                                                                                                            |                 |                              | Yes                                                                                                                                                                                                                                                              |               |                              |

\*Student outcomes were revised starting with AY 2019, and this outcome was measured from Fall 2019 semester

\*\*Outcome 2 corresponds with outcome 3(c) from the previous assessment, and those averages are listed.



PRAIRIE VIEW A&M UNIVERSITY

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**CVEG 4301– Environmental Engineering Design  
Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

**Grade Sheet Showing  
Student and Class Performance in Outcomes**



# PRAIRIE VIEW A&M UNIVERSITY

A Member of the Texas A&M University System

## CVEG 4301– Environmental Engineering Design

Fall 2021

Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE

## Grade Sheet Showing Student and Class Performance in Outcomes

|                                | ABET Criteria 3 (1) |                      |                | ABET Criteria 3 (2) |                      |                |
|--------------------------------|---------------------|----------------------|----------------|---------------------|----------------------|----------------|
|                                | HW# 3               | Water Design Project | % Student Avg. | HW #2               | Water Design Project | % Student Avg. |
| <b>Max Points</b>              | <b>120</b>          | <b>200</b>           | <b>100.0</b>   | <b>140</b>          | <b>300</b>           | <b>100.0</b>   |
|                                | 90                  | 180                  | <b>82.5</b>    | 122                 | 270                  | <b>88.6</b>    |
|                                | 88                  | 185                  | <b>82.9</b>    | 112                 | 275                  | <b>85.8</b>    |
|                                | 86                  | 180                  | <b>80.8</b>    | 110                 | 260                  | <b>82.6</b>    |
|                                | 78                  | 175                  | <b>76.3</b>    | 106                 | 275                  | <b>83.7</b>    |
|                                | 72                  | 165                  | <b>71.3</b>    | 52                  | 260                  | <b>61.9</b>    |
|                                | 84                  | 170                  | <b>77.5</b>    | 98                  | 260                  | <b>78.3</b>    |
|                                | 76                  | 180                  | <b>76.7</b>    | 110                 | 260                  | <b>82.6</b>    |
|                                | 106                 | 180                  | <b>89.2</b>    | 124                 | 270                  | <b>89.3</b>    |
|                                | 82                  | 175                  | <b>77.9</b>    | 128                 | 275                  | <b>91.5</b>    |
|                                | 86                  | 170                  | <b>78.3</b>    | 102                 | 260                  | <b>79.8</b>    |
|                                | 82                  | 185                  | <b>80.4</b>    | 110                 | 275                  | <b>85.1</b>    |
|                                | 77                  | 165                  | <b>73.3</b>    | 96                  | 265                  | <b>78.5</b>    |
|                                | 22                  | 165                  | <b>50.4</b>    | 90                  | 260                  | <b>75.5</b>    |
|                                | 80                  | 170                  | <b>75.8</b>    | 124                 | 260                  | <b>87.6</b>    |
|                                | 86                  | 170                  | <b>78.3</b>    | 118                 | 260                  | <b>85.5</b>    |
|                                | 58                  | 165                  | <b>65.4</b>    | 106                 | 265                  | <b>82.0</b>    |
|                                |                     |                      |                |                     |                      |                |
| <b>Average for whole class</b> | <b>78.3</b>         | <b>86.9</b>          | <b>76.1</b>    | <b>76.3</b>         | <b>88.5</b>          | <b>82.4</b>    |



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**CVEG 4301– Environmental Engineering Design  
Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

**OUTCOME SPECIFIC ASSIGNMENTS  
USED TO ASSESS OUTCOMES**



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**CVEG 4301– Environmental Engineering Design  
Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

**ASSIGNMENTS FOR OUTCOME "1"**

**An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.**

**CVEG 4301– Environmental Engineering Design  
Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

**Title of Assignment**

Homework # 3

**Outcome Measured Using this Assignment**

**Outcome 1**

**An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics**

**Brief Description of the suitability of this assignment for the outcome**

All the problems in this Homework are developed to test the students' ability to identify, formulate and solve complex engineering problems



# PRAIRIE VIEW A&M UNIVERSITY

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## CVEG 4043 – ENVIRONMENTAL ENGINEERING DESIGN

Fall 2021

Homework # 3: Due: October 28, 2021

Raghava R. Kommalapati, Ph.D., PE, BCEE, F. ASCE

Student Name Michael LeBlanc Grade: 106/120

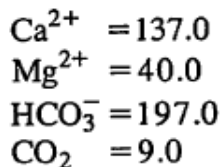
### Topics Covered

Water Treatment-Lime and Soda Softening

### Solve the following problems

1. Problem # 4.18
2. Problem # 4.19
3. Problem # 4.20
4. Problem # 4.22
5. Problem # 4.23
6. Problem # 4.24

4-18. Determine the lime and soda ash dose, in mg/L as  $\text{CaCO}_3$ , to soften the following water to a final hardness of 90.0 mg/L as  $\text{CaCO}_3$ . If the price of lime, purchased as  $\text{CaO}$ , is \$61.70 per megagram (Mg), and the price of soda ash, purchased as  $\text{Na}_2\text{CO}_3$  is \$172.50 per Mg, what is the annual chemical cost of treating  $0.050 \text{ m}^3/\text{s}$  of this water? Assume the lime is 90% pure and the soda ash is 97% pure. The ion concentrations reported below are all mg/L as  $\text{CaCO}_3$ .



4-19. What amount of lime and/or soda ash, in mg/L as  $\text{CaCO}_3$ , is required to soften the Village of Lime Ridge's water to less than 120 mg/L hardness as  $\text{CaCO}_3$ ?

| Compound           | Concentration, mg/L as $\text{CaCO}_3$ |
|--------------------|----------------------------------------|
| $\text{CO}_2$      | 4.6                                    |
| $\text{Ca}^{2+}$   | 257.9                                  |
| $\text{Mg}^{2+}$   | 22.2                                   |
| $\text{HCO}_3^-$   | 248.0                                  |
| $\text{SO}_4^{2-}$ | 32.1                                   |

- 4-20.** Determine the lime and soda ash dose, in mg/L as  $\text{CaO}$  and  $\text{Na}_2\text{CO}_3$ , to soften the following water to a final hardness of less than 130 mg/L as  $\text{CaCO}_3$ . The ion concentrations reported below are all mg/L as  $\text{CaCO}_3$ . Assume the lime is 90% pure and the soda ash is 97% pure.

$$\begin{aligned}\text{Ca}^{2+} &= 210.0 \\ \text{Mg}^{2+} &= 23.0 \\ \text{HCO}_3^- &= 165.0 \\ \text{CO}_2 &= 5.0\end{aligned}$$

- 4-22.** Determine the lime and soda ash dose, in mg/L as  $\text{CaCO}_3$  to soften the following water to a final hardness of less than 120.0 mg/L as  $\text{CaCO}_3$ . If the price of lime, purchased as  $\text{CaO}$ , is \$61.70 per megagram (Mg), and the price of soda ash, purchased as  $\text{Na}_2\text{CO}_3$ , is \$172.50 per Mg, what is the annual chemical cost of treating 1.35 m<sup>3</sup> of this water? Assume the lime is 87% pure and the soda ash is 97% pure. The ion concentrations reported below are all mg/L as  $\text{CaCO}_3$ .

$$\begin{aligned}\text{Ca}^{2+} &= 293.0 \\ \text{Mg}^{2+} &= 55.0 \\ \text{HCO}_3^- &= 301.0 \\ \text{CO}_2 &= 5.0\end{aligned}$$

- 4-23.** Determine the lime and soda ash dose, in mg/L as  $\text{CaCO}_3$ , to soften the following water to a final hardness of less than 90.0 mg/L as  $\text{CaCO}_3$ . If the price of lime, purchased as  $\text{CaO}$ , is \$61.70 per megagram (Mg), and the price of soda ash, purchased as  $\text{Na}_2\text{CO}_3$ , is \$172.50 per Mg. What is the annual chemical cost of treating 0.050 m<sup>3</sup>/s of this water? Assume the lime is 90% pure and the soda ash is 97% pure. The ion concentrations reported below are all mg/L as  $\text{CaCO}_3$ .

$$\begin{aligned}\text{Ca}^{2+} &= 137.0 \\ \text{Mg}^{2+} &= 60.0 \\ \text{HCO}_3^- &= 197.0 \\ \text{CO}_2 &= 9.0\end{aligned}$$

- 4-24.** Determine the lime and soda ash dose, in mg/L as  $\text{CaCO}_3$ , to soften the Kool Artesian (Problem 4-10) water to a final hardness of  $\leq 115$  mg/L as  $\text{CaCO}_3$ . Assume the water temperature as pumped from the ground is 10°C. If the price of lime, purchased as  $\text{CaO}$ , is \$100 per megagram (Mg), and the price of soda ash, purchased as  $\text{Na}_2\text{CO}_3$  is \$200 per Mg, what is the annual chemical cost of treating 0.500 m<sup>3</sup>/s of this water? Assume all the alkalinity is bicarbonate, lime is 88% pure, and soda ash is 98% pure.

Kool Artesian Water

|            |                               |           |      |
|------------|-------------------------------|-----------|------|
| Calcium    | 37.0                          | Silica    | 11.5 |
| Magnesium  | 18.1                          | Sulfate   | 5.0  |
| Sodium     | 2.1                           | Potassium | 1.6  |
| Fluoride   | 0.1                           | Zinc      | 0.02 |
| Alkalinity | 285.0 mg/L as $\text{CaCO}_3$ |           |      |
| pH         | 7.6 units                     |           |      |

NOTE: All units are mg/L as the ion unless stated otherwise

4.18)

GivenPrice of lime ( $\text{CaO}$ ) = \$61.70 per Mg Lime is 90% purePrice of soda ( $\text{Na}_2\text{CO}_3$ ) = \$172.50 per Mg Soda Ash is 97% pure

| Constituent   | Cons | Lime (mg/L as $\text{CaCO}_3$ ) | TH = $\text{Ca}^{+2} + \text{Mg}^{+2}$        |
|---------------|------|---------------------------------|-----------------------------------------------|
| $\text{CO}_2$ | 9    | 9                               | TH = 137 + 40 ✓ = 177 mg/L as $\text{CaCO}_3$ |
| ALK           | 197  | 197                             | ALK = CH = 197 mg/L as $\text{CaCO}_3$ ✗      |
| Mg-40         | 0    | 20                              | NCH = TH - CH                                 |

Total lime ✓ 226

$$\frac{226}{.9} = 251.11 \text{ mg/L as } \text{CaCO}_3$$

$$= (177 - 197) = -20 \text{ mg/L as } \text{CaCO}_3$$

✓ Soda = \$0/yr

$$226 \text{ mg/L as } \text{CaCO}_3 \left( \frac{28}{50} \right) \checkmark = 126.6 \text{ mg/L}$$

$$126.6 \text{ mg/L} \cdot (0.05 \text{ m/s}) \cdot \frac{1000 \text{ L}}{1 \text{ m}^3} \cdot \frac{1 \text{ Kg}}{10^6 \text{ Mg}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{24 \text{ hr}}{1 \text{ d}}$$

$$= 546.9 \frac{\text{Kg}}{\text{d}} \cdot \frac{1 \text{ Mg}}{1000 \text{ Kg}} \cdot \frac{365 \text{ d}}{1 \text{ yr}} = 199.6 \text{ Mg/yr}$$

$$\frac{199.6 (\$61.70)}{.9} \checkmark = \$13,683.7/\text{yr}$$

4.19)

| Constituent   | Cons                            | lime mg/L as $\text{CaCO}_3$ |
|---------------|---------------------------------|------------------------------|
| $\text{CO}_2$ | 4.6                             | 4.6                          |
| Alk           | 280.1                           | 248                          |
| Mg-40         | 0                               | 20                           |
| Total lime    | ✓ 272.6 mg/L as $\text{CaCO}_3$ |                              |

$$\text{TH} = \text{Ca}^{+2} + \text{Mg}^{+2}$$

$$= 257.9 + 22.2$$

$$✓ 280.1 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Alk} = \text{CH} ✓ 248 \text{ mg/L as } \text{CaCO}_3$$

$$\text{NCH} = 280.1 - 248 ✓ 32.1 \text{ mg/L as } \text{CaCO}_3$$

$$120 - 40 ✓ 80 \text{ mg/L as } \text{CaCO}_3 \text{ to be treated}$$

NCH - Treated

$$32.1 \text{ mg/L as } \text{CaCO}_3 - 80 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Soda} = -47.9 \text{ mg/L as } \text{CaCO}_3$$

Since its negative

$$\text{Soda} ✓ 0 \text{ mg/L as } \text{CaCO}_3$$

4.20)

| Constituent      | Cons | lime mg/L as $\text{CaCO}_3$ |
|------------------|------|------------------------------|
| $\text{CO}_2$    | 5    | 5                            |
| Alk              | 165  | 165                          |
| $\text{Mg} - 40$ | 0    | 20                           |
| Total lime       |      | ✓ 90 mg/L as $\text{CaCO}_3$ |

$$\begin{aligned} \text{TH} &= \text{Ca}^{+2} + \text{Mg}^{+2} \\ &= 210 + 23 \\ &= 233 \text{ mg/L as } \text{CaCO}_3 \end{aligned}$$

$$\begin{aligned} \text{Alk} &= \text{CH} \quad \checkmark 165 \text{ mg/L as } \text{CaCO}_3 \\ \text{NCH} &= \text{TH} - \text{CH} \\ &= 233 - 165 \\ &= 68 \text{ mg/L as } \text{CaCO}_3 \end{aligned}$$

$$\frac{90 \text{ mg/L as } \text{CaCO}_3}{0.9} = \cancel{211.1} \text{ mg/L as CaO}$$

$$130 - 40 \quad \checkmark 90 \text{ mg/L as } \text{CaCO}_3$$

$$(68 - 90) \text{ mg/L as } \text{CaCO}_3 = -22 \text{ mg/L} \cdot \left(\frac{56}{50}\right) = -24.64 \text{ mg/L as } \text{Na}_2\text{CO}_3$$

Since it's negative

$$\text{Soda} \quad \checkmark 0 \text{ mg/L}$$

4.22)

| Constituent      | Cons                         | lime (mg/L as $\text{CaCO}_3$ ) |
|------------------|------------------------------|---------------------------------|
| $\text{CO}_2$    | 5                            | 5                               |
| Alk              | 301                          | 301                             |
| $\text{Mg} - 40$ | 15                           | 15                              |
| Excess lime      | $(\text{Mg} - 40)$<br>$< 20$ | 20                              |
| Total lime       |                              | 341                             |

lime = 87% pure = \$61.70 per ( $\text{M}_0$ )

soda = 97% pure = \$172.50 per ( $\text{M}_0$ )

$$\text{TH} = \text{Ca}^{+2} + \text{Mg}^{+2}$$

$$= 293 + 55$$

$$\checkmark 348 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Alk} = \text{CH} \checkmark 301 \text{ mg/L as } \text{CaCO}_3$$

$$\text{NCH} \checkmark \text{TH} - \text{CH} = 348 - 301 = 47 \text{ mg/L as } \text{CaCO}_3$$

$$\frac{\text{M}_{\text{Si}} - \text{M}_{\text{Sr}}}{\text{M}_{\text{Sr}} - \text{M}_{\text{Si}}} = \frac{40 - 10}{55 - 10} = \frac{10}{15}$$

$$\checkmark x = 0.67$$

$$\text{TH}_R(x) + \text{TH}_i(1-x) = \text{TH}_f$$

$$348 \text{ mg/L as } \text{CaCO}_3(0.67) + 40(1-0.67) \checkmark = 246.4 \text{ mg/L as } \text{CaCO}_3$$

From previous Page

Total lime ~~34~~ 341 mg/L as  $\text{CaCO}_3$

$$341 \text{ mg/L as } \text{CaCO}_3 \left( \frac{28}{50} \right) = 190.96 \text{ mg/L}$$

$$190.96 \text{ mg/L} \cdot 1.35 \text{ m}^3/\text{s} \cdot \left( \frac{1000 \text{ L}}{1 \text{ m}^3} \right) \cdot \frac{1 \text{ Mg}}{10^6 \text{ mg}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{24 \text{ hr}}{1 \text{ d}} \cdot \frac{365 \text{ d}}{1 \text{ yr}}$$

$$= \frac{8129.9 \text{ Mg/yr} \cdot (\$61.70)}{0.87} = \text{\$576,565.6} \quad \text{Lime cost per Year}$$

Total lime (87% Pure)

$$\frac{341 \text{ mg/L as } \text{CaCO}_3}{0.87} = \text{\$391.95 mg/L } \text{CaCO}_3$$

$\text{TH}_f - \text{PL}$

$$(120 - 40) \text{ mg/L as } \text{CaCO}_3 = 80 \text{ mg/L as } \text{CaCO}_3$$

$$(47 - 80) \text{ mg/L as } \text{CaCO}_3 = -33 \text{ mg/L as } \text{CaCO}_3$$

Since negative

Soda ~~0~~ 0 mg/L as  $\text{CaCO}_3$

4.23)

Lime = 90% pure = \$61.70/Mg

Soda = 97% pure = \$172.50/Mg

| Constituent     | Cons | lime |
|-----------------|------|------|
| CO <sub>2</sub> | 9    | 9    |
| Alk             | 197  | 197  |
| Mg-40           | 20   | 20   |
| Excess lime     | 20   | 20   |

$$TH = Ca^{+2} + Mg^{+2}$$

$$= 137 + 60$$

✓ 197 mg/L as CaCO<sub>3</sub>

$$Alk = CH \quad \checkmark 197 \text{ mg/L as CaCO}_3$$

$$NCH = \checkmark 0 \text{ mg/L as CaCO}_3$$

FINAL HARDNESS

$$\text{Total lime} = 246 \text{ mg/L as CaCO}_3$$

$$246 \text{ mg/L as CaCO}_3 \cdot \frac{28}{50} \times 137.76 \text{ mg/L}$$

$$137.76 \text{ mg/L} \cdot (0.05 \frac{\text{m}^3}{\text{s}}) \cdot \frac{1000 \text{ L}}{1 \text{ m}^3} \cdot \frac{1 \text{ Mg}}{10^6 \text{ mg}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{24 \text{ hr}}{1 \text{ d}} \cdot \frac{365 \text{ d}}{1 \text{ yr}}$$

$$= \times 217.2 \text{ Mg/yr}$$

$$\frac{217.2 \text{ Mg/yr}}{9} \cdot \$61.70/\text{Mg} = \times \$14,891.63/\text{yr}$$

lime cost per year

Since NCH = 0

Soda ✓ \$0

4.24)

lime = 88% pure = \$100/Mg

Soda = 98% pure = \$200/Mg

| Constituent | Cons                       | lime (mg/L as $\text{CaCO}_3$ ) |
|-------------|----------------------------|---------------------------------|
| Alk         | 285                        | 285                             |
| Mg-40       | 34.5                       | 34.5                            |
| Excess lime | (Mg-40)<br>$20 \times 240$ | 34.5                            |

Total lime ~~354~~ mg/L as  $\text{CaCO}_3$

$$\frac{354}{.88} = \boxed{402.3 \text{ mg/L as } \text{CaCO}_3}$$

Total pure lime

$$\begin{aligned} \text{TH} &= \text{Ca}^{2+} + \text{Mg}^{2+} \\ &= 92.5 + 74.5 \\ &= \checkmark 167 \text{ mg/L as } \text{CaCO}_3 \end{aligned}$$

$$\text{Alk} = \text{CH} = 285 \text{ mg/L as } \text{CaCO}_3$$

$$\begin{aligned} \text{NCH} &= \text{TH} - \text{CH} \\ &= 167 - 285 \\ &= -120 \text{ mg/L as } \text{CaCO}_3 \end{aligned}$$

Since Negative

Split Treatment

Soda  $\checkmark$  0 mg/L as  $\text{CaCO}_3$  also, \$0/yr

$$354 \text{ mg/L as } \text{CaCO}_3 \cdot \frac{28}{50} \times 198.3 \text{ mg/L}$$

$$198.3 \text{ mg/L} \cdot (0.5 \text{ m}^3/\text{s}) \cdot \frac{1000 \text{ L}}{1 \text{ m}^3} \cdot \frac{1 \text{ Mg}}{10^6 \text{ mg}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{24 \text{ hr}}{1 \text{ d}} \cdot \frac{365 \text{ d}}{1 \text{ yr}}$$

$$\times = 3126.8 \text{ Mg/yr}$$

$$\frac{3126.8 \text{ Mg/yr} \cdot (\$100/\text{yr})}{.88} \times \boxed{\$355318.5/\text{yr}}$$

Lime cost Per year

**CVEG 4301– Environmental Engineering Design  
Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

**Title of Assignment**

Water Treatment Plant Design Project

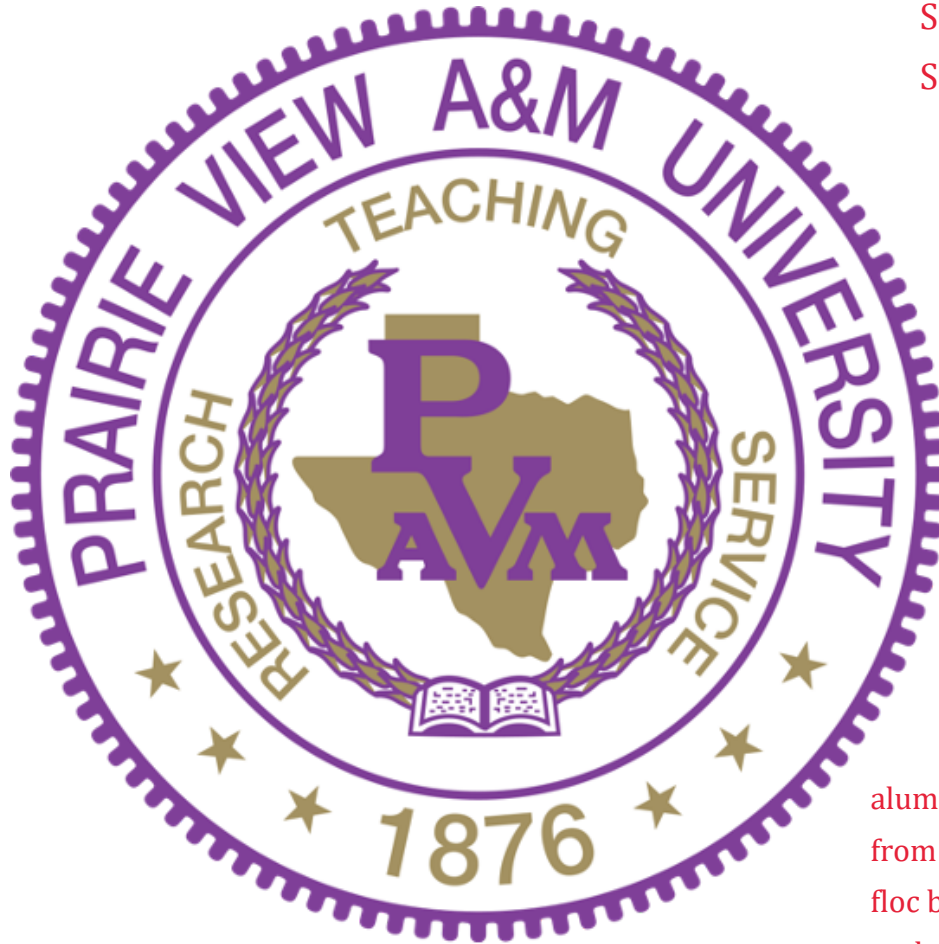
**Outcome Measured Using this Assignment**

**Outcome 1**

**An ability to identify, formulate, and solve complex engineering problems  
by applying principles of engineering, science, and mathematics**

**Brief Description of the suitability of this assignment for the outcome**

In this project, the students need to identify needs and various components for a water treatment plant. Portion of the design include solving complex engineering problems. This project is assigned 200 points out of 500 points for the outcome 1 and 300 for outcome 2.



SLO 1: 185/200

SLO 2: 275/300

## Wastewater Treatment Plant Design - **Part 1**

Brownsville, Texas

CVEG 4301: Environmental Engineering Design

Fall 2021

**Submitted by:**

Autumn Carter

Scott McGary

**Submitted to:**

Dr. Raghava Kommalapati, PE, BCEE, F. ASCE  
Department of Civil and Environmental Engineering

**Due Date:** December 6th, 2021

alumn dose from jar test not  
from alk

floc basins should match sed  
tanks but you have way too  
many units -- not practical

rectangular units are used for  
water

## Table of Contents

|                                            |    |
|--------------------------------------------|----|
| Executive Summary.....                     | 3  |
| I.    Population Growth for Year 2040..... | 4  |
| A. Population Projection.....              | 4  |
| B. Arithmetic Method.....                  | 4  |
| 2 Water Treatment Plant.....               | 6  |
| 3. Source of Water.....                    | 9  |
| 4. Water Quality.....                      | 9  |
| 5. Preliminary Water Treatment Design..... | 11 |
| 6. Water Treatment Method.....             | 11 |
| A. Screening.....                          | 11 |
| B. Rapid Mixing Tank.....                  | 12 |
| C. Coagulation.....                        | 14 |
| D. Flocculation.....                       | 16 |
| E. Sedimentation.....                      | 17 |
| F. Filtration.....                         | 18 |
| G. Disinfection.....                       | 19 |

## List of Tables

|                                                                       |   |
|-----------------------------------------------------------------------|---|
| Table 1. Population Projection of 2040.....                           | 4 |
| Table 2. Water Quality for The Rio Grande River and Nueces River..... | 7 |
| Table 3. Maximum Contaminant Level (State of Texas).....              | 8 |
| Table 4. Detention Times                                              |   |

## Tables of Figures

|                                        |    |
|----------------------------------------|----|
| Figure 1. Population Growth Trend..... | 7  |
| Figure 2. Water Treatment Design.....  | 11 |

### Executive Summary

The objective of this project is to design a water and wastewater plant within a city located in the U.S. that has a population greater than 150,000 people. Contained in this report, is the design for the water treatment plant located in Brownsville, Texas. For water planning purposes, the future population must be estimated. Regarding Brownsville, it has been decided that the arithmetic method will be used to determine future population growth. The city pulls from two different water sources for its drinking water needs: the Rio Grande River and the Nueces River. In preparation for the water treatment process, a water quality analysis must be performed. After doing this, the turbidity and hardness are elevated in both water sources. This is expected due to both water sources being surface water which typically tends to have higher levels of turbidity and hardness.

executive  
summary should  
highlight all the  
salient features of  
your design

## I. Population Growth in the Year 2040

### A. Population Projection

The population project is an important phase of the project because it helps us to observe and provide the present and future population of the community accurately and economically. To calculate the future growth and population for the city of Brownsville in 2040, historical data and trends must first be gathered. The population data were obtained using the U.S. Census Bureau (5) starting from 1900 to 2010. From the table, it can be observed and confirmed that the population growth did consistently increase from 1900 to 2010. Due to the location of the city near the U.S-Mexico border, the city will not face any economic boom. The percent growth method will be chosen to calculate the future population because of the percent growth rate after the year.

### B. Algebraic Method

The algebraic method assumes that the rate of growth of the population is continuously growing each year, which means that each year the population growth in Brownsville is growing at a rapid pace.

$$P = P_o + K(\Delta t)$$

Where,

P = Future Population

P<sub>o</sub> = Initial Population

K = Growth Rate

Δt = change in time (decades)

first present data before discussion the methods

**Table 1. Population Projection of 2040**

| Decade | Population | ΔP     | ΔP    |
|--------|------------|--------|-------|
| 1990   | 99,000     | -      | -     |
| 2000   | 139,700    | 40,700 | 0.291 |
| 2010   | 175,400    | 35,700 | 0.204 |

|      |         |       |       |
|------|---------|-------|-------|
| 2020 | 183,200 | 7,800 | 0.043 |
|------|---------|-------|-------|

|            |               |
|------------|---------------|
| <b>K</b>   | <b>28,066</b> |
| <b>Avg</b> | <b>0.179</b>  |

$$P = 183,200 + (28066)*(2) = \mathbf{239,332}$$

Percent Growth method is displayed below.

$$P_{2040} = P_0(1 + k)^t$$

Where:

$P_{2040}$  = Design Period Population

$P_0$  = Current Population

K = Average population change each decade

t = Number of decades

$$P_{2040} = 183000(1 + 0.179)^2 = 254377.5 \cong 254,378$$

Log Growth = Exponential Growth = Geometric Growth

$$P_{2040} = P_0 e^{k\Delta t}$$

Where:

$P_{2040}$  = Design Period Population

$P_0$  = Current Population

K = Average population change each decade

$\Delta t$  = Elapsed time in years

$$P_{2040} = 183000e^{0.179*2} = 261775.2 \cong 261,775$$

Percent growth method was decided because the growth followed this pattern more than constant growth. The future population for Brownsville, Texas was determined to be 254,378 people for the year 2040. The census for 2020 was used to calculate the future population, which was required for the project's design criteria of 20 years, to get a precise population estimate.

how does this estimate compare t the city's own estimates?

## 2. Water Treatment Plant

From the population, it can be determined the water quantity that will be treated as water demand. The water demand for the different factors is shown below. The water demand for Brownsville will be determined from the fire demand calculated along with the max hourly quantity of water which will be used to design the water treatment plant. “The current estimated per capita raw water demand is about 144 gallons per person per day. With the successful implementation of advanced water conservation measures (i.e. high-efficiency washing machines, toilets, showerheads), the per capita demand can be gradually reduced conservatively by as much as 15 gallons per person per day by the year 2025.” (Brownsville Comprehensive Plan; Source 1) So for the year 2040, a water demand of 120 will be used.

$$AADF = Pop * Q_{demand}$$

$$254,378 * 120 \text{ gal/c*d} = 30.5 \text{ MGD}$$

$$\text{Max. Hourly Flow} = 30.5 \text{ MGD} * 2.7 = 82.42 \text{ MGD}$$

$$\text{Max. Daily Flow} = 30.5 \text{ MGD} * 1.8 = 54.9 \text{ MGD} \quad \text{Design Q?}$$

$$\text{Max. Weekly Flow} = 30.5 \text{ MGD} * 1.4 = 42.7 \text{ MGD}$$

$$\text{Max. Monthly Flow} = 30.5 \text{ MGD} * 1.2 = 36.6 \text{ MGD}$$

$$Q_{fire} = 1020\sqrt{P} * (1 - 0.01\sqrt{P}); P = \text{thousands}$$

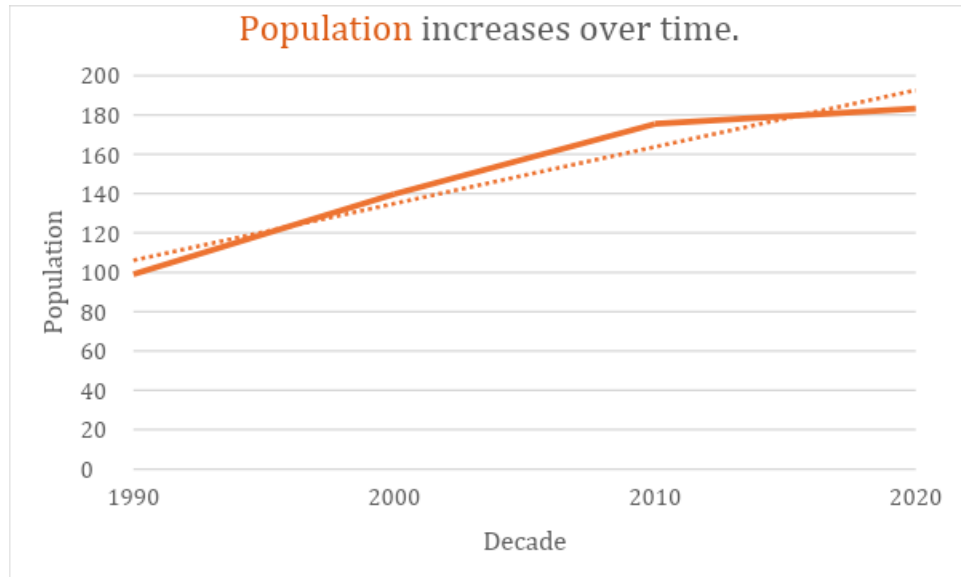
$$Q_{fire} = 1020\sqrt{254.378} * (1 - 0.01\sqrt{254.378}) = 13673.56 \text{ GPM}$$

$$13673.56 \text{ GPM} * 60 \text{ min/hr} * 24 \text{ hrs/day} = 19.69 \text{ MGD}$$

$$Q_{total} = \text{Max hourly} + Q_{fire} = 82.42 \text{ MGD} + 19.69 \text{ MGD} = 102.1 \text{ MGD}$$

This  $Q_{total}$  will be used to design the maximum flow of water for the pipes.

what is your design Q?



**Figure 1. Population Growth Trend**

From the collection of the census data the rate of change can be obtained and can be converted into a table and chart displaying the information. As seen in figure 1, it is observed that the population has increased by a percentage over the last 30 years.

**Table 2. Water Quality**

| Water Sources    |       | Rio Grande     | Nueces River |
|------------------|-------|----------------|--------------|
| Constituent      | Units | Concentrations |              |
| Turbidity        | NTU   | 34.1           | 58.1         |
| Total Alkalinity | mg/L  | 56.5           | 150          |
| Calcium          | mg/L  | 29.4           | 22.5         |
| Magnesium        | mg/L  | 3.625          | 6.16         |
| pH               | mg/L  | 8.34           | 8.34         |

|                        |      |       |      |
|------------------------|------|-------|------|
| Total Dissolved Solids | mg/L | 132.5 | 230  |
| Fluoride               | mg/L | 0.52  | 0.47 |
| Chloride               | mg/L | 40    | 49   |
| HAA5                   | ug/L | 16    | 14   |
| Total Hardness         | mg/L | 57    | 130  |

It is always important to know the maximum contaminant levels set by the state of Texas. The MCL and the respected units are listed below to compare our sources to the max levels of contaminants to see what treatment methods should be considered to properly clean and remove solids from surface water.

**Table 3. Maximum Contaminant Level (State of Tx.)**

| Constituent      | MCL | Units |
|------------------|-----|-------|
| Turbidity        | 4   | NTU   |
| Total Alkalinity | 200 | mg/L  |
| Calcium          | 80  | mg/L  |
| Magnesium        | 30  | mg/L  |
| pH               | 500 | mg/L  |
| TDS              | 4   | mg/L  |
| Fluoride         | 5   | mg/L  |

|          |     |      |
|----------|-----|------|
| Chloride | 60  | ug/L |
| HAA5     | 120 | mg/L |

### 3.Source of Water

Due to the location of Brownsville, the nearby sources of water will generate enough demand to supply the city. The primary source of groundwater for the city comes from the Rio Grande River. For the project, it is assumed that Brownsville uses 100 percent surface water, where 50 percent comes from the Rio Grande River while the other 50 percent comes from the Nueces River.

#### - Rio Grande River

The Rio Grande River is the main source of surface water that is used in the Brownsville area at present time. Using this source will be beneficial to know what contaminants are being consumed, and how we can make changes to this water source.

#### - Nueces River

The Nueces River will also be surface water we will utilize through this design. For this project, the water quality from the two rivers, the Rio Grande River and the Nueces River was obtained from TCEQ and placed their values in the tables below. The water will then be combined to have an accurate method of treatment for both water sources at one water treatment plant.

### 4.Water Quality

With the main source of drinking water descending from surface water there are a lot of regulations to abide by for healthy human consumption. With expanding population growth and location of water sources a lot of pollutants get into the water then get sent to surrounding areas, which includes the Rio Grande Valley. In an area with an abundant value of individuals, most homes will have some type of filtration system to provide an efficient amount of sterilized clean water throughout their residence.

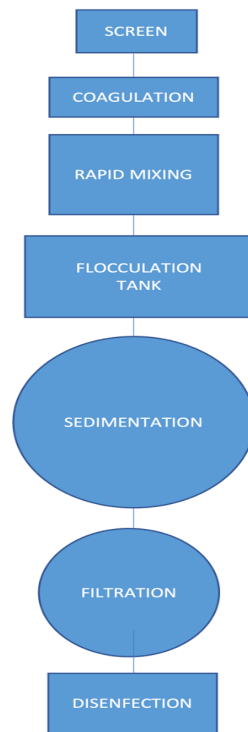
Reverse Osmosis is a form of filtration system that is recommended in the city of Brownsville. Reverse Osmosis removes sediment and chlorine from water with a pre-filter

before it forces water through a semipermeable membrane to remove dissolved solids. After water exits the reverse osmosis (RO) membrane, it passes through a postfilter to polish the drinking water before human consumption and/or usage. There are three filters used within the system; sedimentation filter- reduces particles such as dirt and rust, carbon filter- reduces volatile organic compounds, chlorine, and other contaminants that give water a bad taste or odor. Lastly, a semipermeable membrane removes up to ninety-eight percent (98%) of total dissolved solids (TDS).

The current estimated per capita raw water demand is about “144 gallons per person per day. With the successful implementation of more high-efficiency appliances and practices of conservation measures, the per capita demand can be gradually reduced conservatively by as much as 15 gallons per person per day by the year 2050.” (Brownsville Comprehensive Plan; Source 1). We will use 120 gallons per person per day.

thats too low if the current demand is 144

## 5. Preliminary Water Treatment Design



**Figure 2. Water Treatment Design**

## 6. Water Treatment Method

### **A. Screening**

Screening is the first step of operation at all water treatment plants. The screen is the operative device used to retain solids found in the water such as logs and branches. The main purpose of screening is to remove solid materials that could cause damage to other process equipment, cause a reduction in efficiency of the operation system, and taint waterways. There is a classification of three types of screens which are coarse, fine, and micro screens. In this design, we will utilize coarse screens. Coarse screens have a clear space opening size that ranges from 3”- 6”, the screen is composed of parallel bars, rods or wires, wire mesh, or a perforated plate with an opening that is circular or rectangular. These openings are called “bar rack” which are

used to remove coarse solids such as large objects that may clog or cause damage to other apparatus.

The types of coarse screens include mechanically and manually cleaned bar screens to help with the process of screening. A mechanically cleaned bar screen is designed to extract large solids, rags, and debris. The opening size ranges from 0.25 to 1.5 inches, the bars are also set to 0-30° from vertical. This screening is predominately used in new installations because of the large number of advantages relative to other screens. Manual screens are designed to remove large solids, rags, and debris like mechanical screens. Its opening is 1 to 2 in., and the bars are set at 30 to 45° from vertical to facilitate cleaning. Manually bar screens are primarily used in older or smaller treatment facilities, or in bypass channels. Some advantages for both would be that manually cleaned screens require the bare minimum or no equipment maintenance and provide an excellent alternative for smaller plants with fewer screenings. Mechanically screens have a lower labor cost and offer the gain of improved flow conditions and screen captivity.

## **B. Rapid Mixing Tank**

The rapid mixing tank is the first chamber in which the water will be entering for the water treatment process. The rapid mixing tank provides an aggressive mixing to ensure a uniform distribution of the coagulant used which in this treatment will be alum. With the water demand for Brownsville, the volume for different detention times can be calculated using the formula below.

$$\Theta = V/Q$$

Where;

Q = water flow

V = Total Volume for Rapid Mixing Tanks

$\Theta$  = Detention Time

For a rapid mixing tank, there are certain design criteria that is required from Texas Administrative Code requiring the volume of a tank not to exceed (8) cubic meters. The detention time for the tank is also required to be in a range of 20 to 60 seconds

with G values ranging from (750 – 1000) per second units (s-1). With these design parameters, calculations can be made to maximize the tanks.

$$V = Q * \theta$$

never mentioned how you decided on the design Q

The calculation for the different volumes that can be produced from different detention times can help choose a more viable option for a growing city. With the population growing at a constant rate the thirty (30) second detention allows for a larger number of tanks that can be efficiently used. The plant can have the option to run at a much slower detention time offering a more effective treatment at low flow throughout the different times of the day and the year.

$$Volume = 54.9 \text{ MGD} * 10^6 \frac{\text{gal}}{\text{d}} * \frac{3.785 \text{ L}}{1 \text{ gal}} * \frac{1 \text{ m}^3}{1000 \text{ L}} * 30 \text{ secs} * \frac{1 \text{ min}}{60 \text{ sec}} * \frac{1 \text{ hr}}{60 \text{ min}} * \frac{1 \text{ d}}{24 \text{ hr}} = 72.15 \text{ m}^3$$

$$72.15 \text{ m}^3 > 8 \text{ m}^3$$

$$\frac{72.15 \text{ m}^3}{8 \text{ m}^3} = 9.02 \approx 10 \text{ Tanks}$$

ok

The volume exceeds the recommended design criteria; there must be a total of ten tanks. Since the number of tanks is determined, the volume can be maximized by each tank since the required tank size is eight cubic meters.

$$10 * 8 \text{ m}^3 = 80 \text{ m}^3$$

**Table 4 Detention Times**

| Detention (sec) | Volume (m <sup>3</sup> ) | Number of Tanks | Volume of each tank (m <sup>3</sup> ) | Total Volume (m <sup>3</sup> ) |
|-----------------|--------------------------|-----------------|---------------------------------------|--------------------------------|
| 20              | 48.10                    | 8               | 6.01                                  | 64                             |
| 30              | 72.15                    | 10              | 7.215                                 | 80                             |
| 40              | 96.20                    | 14              | 8.02                                  | 112                            |
| 50              | 120.30                   | 16              | 7.52                                  | 128                            |
| 60              | 144.30                   | 18              | 8.02                                  | 144                            |

The possibility of the different detention times and larger tank volumes are displayed above but the most reasonable option will be a rapid mixing tank with a thirty-second detention time. With having a moderate detention time there is no need to have an aggressive mixing for a long period when a moderate mixing can achieve similar values for a lower cost.

$$G = 850s^{-1}$$

$$P = G^2 * V * \mu$$

Where;

P = Power

G = Velocity Gradient

$\mu$  = Dynamic Viscosity

$$(850s^{-1})^2 * 80m^3 * 1.002 * 10^{-3} * \frac{N*s}{m^2} = 57,915.6 \frac{N*s}{m^2}$$

$$Power = 57.92 kWh$$

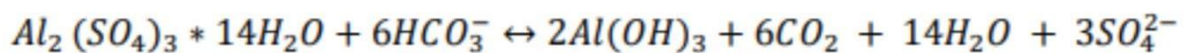
According to PayLess power in Brownsville, TX “Industrial Texas electricity consumers in both Brownsville and the state of Texas can get average energy rates as low as 5.57 cents per kWh” (PayLess power Source 2) Using this rate the total cost of electricity for the rapid mixing tank is calculated below.

*Monthly Electricity cost for rapid mixing tank*

$$57.92 kWh * \frac{\$0.057}{kWh} * \frac{24hr}{1day} * \frac{30days}{1month} = \$2,377.04$$

### C. Coagulation-

The addition and rapid mixing of a coagulant to form a precipitate, resulting in the destabilization of the colloidal and fine suspended solids and the initial aggregation of the destabilized particles. This is done by turning small particles of color, turbidity, and bacteria into larger flocs either as precipitate or suspended particles which can then be removed. Regarding colloid stability they are too small to settle in a reasonable time, they are too small to be trapped in the pores of a filter, colloids also possess a negative charge that repels other particles. Using a jar test apparatus, the water should be tested at different PH levels to measure the different amounts of alum dosages necessary that can be launched into the treatment.



Where;

Molecular Weight of Alum = 594 g/mo

Molecular Weight of Bicarbonate = 366 g/mol

Molecular Weight of Alum Precipitate= 156 g/mol

The table below will show the water sources utilized to disburse water to Brownsville and their alkalinity values.

| Water Sources    | Alkalinity (mg/l) |
|------------------|-------------------|
| Rio Grande River | 56.5 mg/l         |
| Nueces River     | 150 mg/l          |

Let's assume an equivalent amount of water will be pulled from each water source each day.

$$Avg\ Alkalinity = \frac{56.5 \frac{mg}{l} + 150 \frac{mg}{l}}{2} = 103.25 \frac{mg}{l}$$

$$Max\ Alum\ Dosage = \frac{Avg\ Alkalinity * Alum\ MW}{Alkalinity\ MW} = \frac{103.25 \frac{mg}{l} * 594 \frac{g}{mol}}{366 \frac{g}{mol}} = 167.57 \frac{mg}{l} \text{ of Alum}$$

The maximum amount of alum that can be used in the water is 167.57 mg/l. To maintain a stable amount of alkalinity in the water and to not use the maximum amount that could possibly surpass the amount, we'll reduce the dosage amount by 25%. The following calculation will show the reduced amount of alum that can be used and the cost of alum per month.

$$167.57 \frac{mg}{l} * (0.25) = 41.89 \frac{mg}{l}$$

$$167.57 \frac{mg}{l} - 41.89 \frac{mg}{l} = 125.67 \frac{mg}{l}$$

you conduct jar test to find Alum dosage

Alkalinity left after treatment,

$$103.25 \frac{mg}{l} - \frac{125.67 \frac{mg}{l} * 366 \frac{g}{mol}}{594 \frac{g}{mol}} = 25.81 \cong 26 \frac{mg}{l}$$

$$Remaining\ Alkalinity = 26 \frac{mg}{l}$$

Alum per month,

$$167.57 \frac{mg}{l} * 54.9\ MGD * 10^6 * \frac{3.785\ L}{1\ gal} * \frac{1\ kg}{10^6} * \frac{30d}{1\ month} = 1,044,613.79 \frac{kg}{mon}$$

Cost of alum per ton = \$425.00

$$Cost\ of\ alum\ per\ kilogram = \frac{1\ ton}{907\ kg} * \frac{\$425.00}{1\ ton} = \$0.47/kg$$

Alum cost per month,

$$1,044,613.79 \frac{kg}{month} * \frac{\$0.47}{kg} = \$490968.48$$

## D. Flocculation

The slow stirring or gentle agitation to aggregate the destabilized particles and form a rapid settling floc.

$$\text{Floc Produced} = \frac{167.57 \frac{mg}{l} * 156 \frac{g}{mol}}{594 \frac{g}{mol}} = 44.0 \frac{mg}{l}$$

Floc Produced Per month,

=

$$\left(44.0 \frac{mg}{l}\right) * (54.9 MGD) * \left(\frac{10^6 gal}{1 day}\right) * \left(\frac{1 kg}{10^6 mg}\right) * \left(\frac{3.785 L}{1 gal}\right) * \left(\frac{30 day}{1 month}\right) = 274291.38 \frac{kg}{month}$$

The flocculation chamber is a necessary part of the water treatment for the water to reduce its turbulence for its flow to the sedimentation tank. The flocculation segment of the treatment will be divided into three separate chambers for the reduction of turbulence. For the design criteria, the length of the chamber and the depth will be kept the same as the baffles that will be providing mixing will need to have the necessary space to provide the uniform mixing required. For alum and iron salts

$\Theta$  is typically 15 to 30 minT theta is a min of 30 min preferably higher

G is typically 20 to 75/sec

GT is typically 50,000 to 100,000 GT

$$Q = 54.9 MGD$$

$$G_1 = 75 s^{-1}, G_2 = 40 s^{-1}, G_3 = 20 s^{-1}$$

$$\Theta = 30 min$$

$$L = D; D = 4.0 m$$

$$V_{total} = 54.9 * \left(\frac{10^6 gal}{1 day}\right) * 30 min * \left(\frac{3.785 L}{1 gal}\right) * \left(\frac{1 m^3}{1000 L}\right) * \frac{1 hr}{60 min} * \frac{1 day}{24 hr} = 4329.1 m^3 \cong 4400 m^3$$

The total volume for the flocculation tanks is calculated with the use of the flow rate and

the detention time. Now, the volume for each tank will be calculated. The number of flocculation

tanks will be equal to the number of rapid mixing tanks that will be used in the tank to make sure

there is an even amount of coagulant in each batch of water being treated. decide number of floc basins to

$$V_{tank} = \frac{V_{total}}{\# Tanks} = \frac{4400 m^3}{10} = 440 m^3 \quad \text{match the sed tanks}$$

The volume for each tank will now be divided into three sections that will help reduce the

too many floc basins

turbulence in the water for the floc to remain suspended until the floc reach the sedimentation tank.

$$V_{\text{tank section}} = \frac{V_{\text{tank}}}{3} = \frac{440 \text{ m}^3}{3} = 146.6 \cong 147 \text{ m}^3$$

$$V_{\text{tank section}} = L * W * D \rightarrow V_{\text{tank}} = W * D^2 \rightarrow W = \sqrt{\frac{V_{\text{tank section}}}{D^2}}$$

$$W = 8.5 \text{ m}$$

The tank dimension for each section will be as follows.

$$L = 4.5 \text{ m}; W = 8.5 \text{ m}; D = 4 \text{ m}$$

The full flocculation tank dimensions will be as follows. The length of the full flocculation tank will be three times the length of the section since it is divided into three sections.

$$L = 13.5 \text{ m}; W = 8.5; D = 4 \text{ m}$$

For each section of the flocculation section, there will be different mixing gradients that will be used. The power for each section is calculated below.

$$P = G^2 * V * \mu$$

Section 1

$$(75 \text{ s}^{-1})^2 * 147 \text{ m}^3 * \left(1.002 * 10^{-3} \frac{\text{N*s}}{\text{m}^2}\right) * \frac{1 \text{ Watt}}{1 \frac{\text{N*s}}{\text{m}^2}} * \frac{1 \text{ kW}}{1000 \text{ Watt}} = 0.828 \text{ kW}$$

Section 2

$$(40 \text{ s}^{-1})^2 * 147 \text{ m}^3 * \left(1.002 * 10^{-3} \frac{\text{N*s}}{\text{m}^2}\right) * \frac{1 \text{ Watt}}{1 \frac{\text{N*s}}{\text{m}^2}} * \frac{1 \text{ kW}}{1000 \text{ Watt}} = 0.236 \text{ kW}$$

Section 3

$$(20 \text{ s}^{-1})^2 * 147 \text{ m}^3 * \left(1.002 * 10^{-3} \frac{\text{N*s}}{\text{m}^2}\right) * \frac{1 \text{ Watt}}{1 \frac{\text{N*s}}{\text{m}^2}} * \frac{1 \text{ kW}}{1000 \text{ Watt}} = 0.059 \text{ kW}$$

$$\text{Total Power Per Tank} = 1.12 \text{ kW}$$

$$\text{Total Power} = \text{Total Power Per Tank} * 10 = 11.23 \text{ kW}$$

$$\text{Cost per month} = 11.23 \text{ kW} * \frac{\$0.057}{\text{kWh}} * \frac{24 \text{ hr}}{1 \text{ day}} * \frac{30 \text{ days}}{1 \text{ month}} = \$460.92$$

## E. Sedimentation-

The physical water treatment process of allowing particles in suspension in water to settle out of the suspension under the effect of gravity. The sedimentation tank will get the flow of water and contain the suspended solids for them to settle. The water will enter the sedimentation at the inlet zone continuing into the settling zone where the suspended solids will settle to the

base. The water will then, at that point, continue through the outlet zone while the suspended solids, which are now floc, will settle furthermore go to the sludge zone. The important plan rules for the sedimentation tank will be as follows. Each flocculation basin will be followed by a sedimentation chamber that will provide settling for the incoming floc. The design criteria for each tank will be calculated below.

$$\begin{aligned}
 Q &= 54.9 \text{ MGD} \\
 OFR &= 1000 \text{ gal/ft}^2 \text{ day} * \frac{3.785 \text{ L}}{1 \text{ gallon}} * \left( \frac{1 \text{ m}^3}{1000 \text{ L}} \right) * \frac{3.28 \text{ ft}}{1 \text{ meter}} * \frac{3.38 \text{ ft}}{1 \text{ meter}} = \\
 A &= \frac{Q}{OFR} = \frac{54.9 \text{ MGD} * \frac{3.785 \text{ L}}{1 \text{ gallon}} * \left( \frac{1 \text{ m}^3}{1000 \text{ L}} \right)}{40 \left( \frac{\text{m}^3}{\text{m}^2 \text{ day}} \right)} = 5194.9 \text{ m}^2 \\
 \text{Area per tank} &= \frac{5194.9 \text{ m}^2}{10} = 519.5 \text{ m}^2 \quad \text{ten is way too many for this flow} \\
 \text{Diameter per tank} &= \sqrt{\frac{5194.9 \text{ m}^2 (4)}{\pi}} = 25.71 \text{ m} = D \\
 V_{total} &= 54.9 * \left( \frac{10^6 \text{ gal}}{1 \text{ day}} \right) * \left( \frac{3.785 \text{ L}}{1 \text{ gal}} \right) * \left( \frac{1 \text{ m}^3}{1000 \text{ L}} \right) * 6 \text{ hr} * \frac{1 \text{ day}}{24 \text{ hr}} = 51949.13 \text{ m}^3 \quad \text{rectangular units are used for water} \\
 \text{Depth} &= \frac{V_{total}}{\text{Total Area}} = \frac{51949.13 \text{ m}^3}{5195 \text{ m}^2} = 10 \text{ m} \\
 AS &= 4w^2 = \sqrt{\frac{5194.9 \text{ m}^2}{4}} = w = 36 \text{ m}; L(4)(36) = 144 \text{ m} \\
 V_{per \text{ tank}} &= \frac{51949.13 \text{ m}^3}{10} = 5194.91 \text{ m}^3
 \end{aligned}$$

The dimensions for the sedimentation tanks will be 25.7 meters in diameter and 10 meters in depth.

## F. Filtration

Filtration is the process that removes suspension in water, this removal is taken place by multiple mechanisms of filtration which are; mechanical screening, sedimentation, flocculation, interception, and impaction. There are three types of granular medium filtration which is depth, pressure, and slow sand filtration. For treatment purposes, we'll focus on depth (gravity) filtration, where we have slow sand filtration which only uses sand for filtration purposes. This process causes too much labor because of excessive dumping of sand. Whereas rapid sand will be useful due to its tight pores to capture remaining sediments in the water. Also, the rapid sand design is multi-media utilizing both sand and carbon for filtration purposes.

The number of filters can be determined by the following equation below.

$$N = 0.0195 * Q^{0.5}$$

$$N = 0.0195(54.9 * \left(\frac{10^6 \text{ gal}}{1 \text{ day}}\right) * \left(\frac{3.785 \text{ L}}{1 \text{ gal}}\right) * \left(\frac{1 \text{ m}^3}{1000 \text{ L}}\right)) = 8.96 \cong 9 \text{ filters} \quad \text{ok}$$

The total amount of filters calculated was 9 filters, however, the use of **10 filters** will be necessary for backwash purposes when one filter goes offline. It's also beneficial to use an even number of tanks for filtration. Regarding calculation, we will continue to use 9 filters for accuracy. The flow rate for a rapid sand filter is designed to criteria that are standardized by TAC to be 2 GPM per square foot for the optimal flow for the process of filtration.

$$A_{\text{total Filters}} = \frac{Q}{FR}$$

$$A_{\text{total Filters}} = \frac{54.9 * 10^6 \frac{\text{gal}}{\text{d}}}{(2 \frac{\text{gal}}{\text{min} * \text{ft}^2}) (\frac{1440 \text{ min}}{1 \text{ day}}) (\frac{10.76 \text{ ft}^2}{1 \text{ m}^2})} = 1771.6 \text{ m}^2$$

$$D = 6 \text{ m} \quad \frac{L}{W} = 1.3$$

$$A = L * 1.3 * W \quad A = W^2 * 1.3$$

$$W = \sqrt{\frac{A}{1.3}} = \sqrt{\frac{130.17 \text{ m}^2}{1.3}} = 10.1 \text{ m}$$

$$L = 1.3W \quad (1.3)(10.1) = 13.13 \text{ m}$$

Next, the total amount of water needed for the backwash needs to be calculated. The formula and the calculations are displayed below:

*Backwash = time of wash \* filter area \* rise of backwash*

$$(10 \text{ min}) * (12610.24 \text{ ft}^2) * 24 \frac{\text{in}}{\text{min} * \text{ft}} * \frac{1 \text{ ft}}{12 \text{ in}} = 252204.8 \text{ ft}^3 = 7141.64 \text{ m}^3$$

$$\% \text{ of backwash} = \frac{7141.64 \text{ m}^3}{54.9 * 10^6 \text{ m}^2} * 100 = 0.013\%$$

## G. Disinfection-

Disinfection is the last method used in a water treatment plant; it is designed to eliminate pathogenic microorganisms that are remaining in treated water. If pathogens remain in the water it causes water-borne diseases that if consumed it can lead to severe illness and even death.

Chlorine disinfection is the most widely used form of disinfectant; more subtle forms of disinfection technology include ozonation and ultraviolet (UV) radiation.

The disinfection and storing process requires the total amount of chlorine needed to treat the inflow of water which is calculated to determine the flow rate. The hydraulic retention time is 15 minutes. The L:W ratio= 10:1 and the depth is 5-15feet; the first step in clarifying the

dimensions of the storage tank is to calculate the volume of the flow rate with a detention time of 15 minutes.

$$Q = 54.9 \text{ MGD}$$

$$\Theta = 15 \text{ minutes}$$

$$V_{total} = 54.9 * \left( \frac{10^6 \text{ gal}}{1 \text{ day}} \right) * 15 \text{ min} * \left( \frac{3.785 \text{ L}}{1 \text{ gal}} \right) * \left( \frac{1 \text{ m}^3}{1000 \text{ L}} \right) * \frac{1 \text{ hr}}{60 \text{ min}} * \frac{1 \text{ day}}{24 \text{ hr}} = 2164.54 \text{ m}^3$$

Next, we determine the volume per tank with a total of 7 tanks being utilized, so that the disinfection process will happen equally, and all pathogenic organisms will be eliminated. Then determine L and W to design the proper storage tanks.

$$V \text{ per tank} = \frac{2164.54 \text{ m}^3}{7 \text{ tanks}} = 309.2 \text{ m}^3$$

$$\frac{L}{W} = 10 \text{ D} = 3 \text{ m}$$

$$V = L * W * D = 10W^2D$$

$$W = \sqrt{\frac{V}{10D}} = \sqrt{\frac{309.22 \text{ m}^3}{7 \text{ tanks}}} = 3.2 \text{ m}$$

$$309.22 \text{ m}^3 = L * (3.2) * (3) = 10(3.2)^2 3$$

$$L = 32 \text{ m } W = 3.2 \text{ m } D = 3 \text{ m}$$

This method was first used over a century ago and is still used today. Chlorination is a chemical disinfection method that uses various types of chlorine or chlorine-containing substances for the oxidation and disinfection of what will be the potable water source. It is a very popular method of water disinfection that has been used for many years. It has been shown to be effective for killing bacteria and viruses. Although chlorination does have some drawbacks, it continues to be the most popular, dependable, and cost-effective method of water disinfection

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PRAIRIE VIEW A&M UNIVERSITY

A Member of the Texas A&M University System

**CVEG 4301– Environmental Engineering Design  
Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

**ASSIGNMENTS FOR OUTCOME "2"**

**an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors**

**CVEG 4301– Environmental Engineering Design  
Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

**Title of Assignment**

Homework #2

**Outcome Measured Using this Assignment**

**Outcome 2**

**an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors**

**Brief Description of the suitability of this assignment for the outcome**

This homework is designed to test students ability to provide preliminary desing details for different treatment units



# PRAIRIE VIEW A&M UNIVERSITY

A Member of the Texas A&M University System

## CVEG 4043 – ENVIRONMENTAL ENGINEERING DESIGN FALL 2021

Raghava Kommalapati, PhD, PE, BCEE, F. ASCE

Homework #2: October 25, 2021

Student Name Shadarica Lynch Grade 128/140

1. Explain all of the following
  - (i) Explain in detail any 2 methods to estimate the population
  - (ii) Classify the water and wastewater treatment methods and discuss those methods with at least 2 examples for each
  - (iii) Discuss (i) MCL and MCLG and (ii) Surface Water Treatment Rule
  - (iv) Explain the different municipal water uses and the factors that affect water use.
2. A planned community has a population of 63,000 people and is growing at 8.5% per decade. What is the likely average daily water demand 20 years from now? What are the annual water requirements for the city? What is fire demand? Assume the annual average per capita demand of 425 L/C-d and the . What would be the capacity that should be used for the distribution system? The monthly, weekly, daily and hourly max factors are 1.2, 1.4, 1.8 and 2.7, respectively.
3. Determine the **total fire demand** if the city has several buildings with the following characteristics. Determine the fire demand in m<sup>3</sup>/d and gallons/day.

|                                       |                       |
|---------------------------------------|-----------------------|
| Wood frame construction (C= 1.5)      | 162000 m <sup>2</sup> |
| Ordinary construction (C = 1)         | 95000 m <sup>2</sup>  |
| Non-combustible construction (C= 0.8) | 128200 m <sup>2</sup> |
| Concrete (fire resistive, C = 0.6)    | 119000 m <sup>2</sup> |
4. Design a rectangular sedimentation tank (L/W is 4) for a max weekly flow with a hydraulic retention time of 3 hours, and a surface overflow rate of 50 m<sup>3</sup>/m<sup>2</sup>.d for a town with a population of 250,000 and average daily water demand is 450 L/capita. The monthly, weekly, and daily factors are 1.2, 1.4, and 1.8, respectively. The area of each tank should be limited to 8000 m<sup>2</sup>. Determine the tank dimensions (L,W, and D) and the number of tanks needed. What is the horizontal flow-through velocity in the rectangular basin
5. A primary clarifier at PVAMU wastewater treatment plant receives 15,000 m<sup>3</sup>/d of wastewater with a solids concentration of 220 mg/l and BOD of 260 mg/L. What are the solids loading(kg/d) and the BOD loading (kg/d) to the sedimentation tank? Also, if the

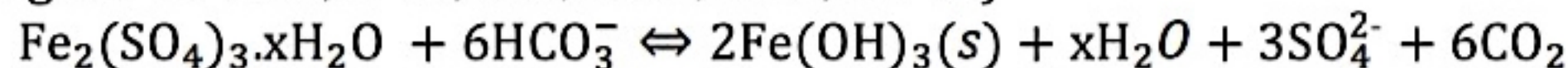
clarifier's diameter is 36 meters, what is the overflow rate (hydraulic loading rate,  $\text{m}^3/\text{d}\cdot\text{m}^2$ ) and solids loading rate ( $\text{kg}/\text{d}\cdot\text{m}^2$ ).

6. Tri-cities of Waller, Hempstead and Prairie View are required to change their water source from groundwater to surface water by year 2030 to reduce the damage due to subsidence caused by excessive groundwater withdrawal. The County Judge as well the three Mayors, have decided to hire our class participants to design a new water treatment unit that utilizes surface water from the rivers nearby. County already obtained water quality data using some contracted labs.

Hardness - 75 mg/l as  $\text{CaCO}_3$ , Turbidity - 8 turbidity units, Taste due to organic matter, Suspended solids - 40 mg/l, It is anticipated that Pathogenic microorganisms will be present.

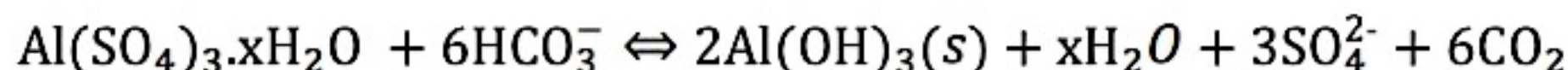
Please recommend to the cities and the county what treatments are necessary for getting this water to the public. First **explain specific treatments** for each of the above water characteristics if treatment is necessary (if no treatment is needed, discuss it as well). Also, **draw a detailed flow sheet that shows all the different treatment units at your proposed plant.**

7. Coagulant dosage and optimum pH were determined to be 50 mg/l of ferric sulfate  $[\text{Fe}_2(\text{SO}_4)_3]$  and 6.6 respectively from Jar tests. The bicarbonate alkalinity in the water is found to be 20 mg/l as ion. The plant treats 40,000  $\text{m}^3/\text{day}$  of water and has 25 mg/l of suspended and colloidal solids. The ferric salt reaction in water is given below: (Atomic Weights: Fe-55.9, C-12, H-1, O-16, S-32, Ca-40)



How much alkalinity (mg/l as  $\text{CaCO}_3$ ) will remain in water? If alkalinity is deficient then how much ferric salt will need to be neutralized and how do we neutralize the water?

8. Coagulant dosage and optimum pH were determined to be 40 mg/l of alum  $[\text{Al}_2(\text{SO}_4)_3]$  and 6.6 respectively from Jar tests. The bicarbonate alkalinity in the water is found to be 30 mg/l as  $\text{CaCO}_3$ . The plant treats 12,500  $\text{m}^3/\text{day}$  of water and has 25 mg/l of suspended and colloidal solids. The ferric salt reaction in water is given below: (Atomic Weights: Fe-55.9, C-12, H-1, O-16, S-32, Ca-40)



- (i) What would be the yearly cost of coagulant if it costs \$315 per 100 Kg and is available at 80% purity?
- (ii) How much floc (precipitate) would be produced per day for coagulation of water and estimate the total solids (including floc) produced in a sedimentation basin if the basin removes 85% of the incoming solids and all the precipitate.

# Problem 1

i) Arithmetic Method: assumes the continuation of the amount of population change observed

$$\frac{dP}{dt} = k \quad P = P_0 + kt$$

Ratio Method: projects population growth for a sub-area using population projections for a larger or parent population

ii) Treatment methods are broken down into chemical, physical, and biological

- chemical is the removal or treatment of solids  
ex: coagulation and chlorination

- physical is the change in water quality through physical forces  
ex: sedimentation and screening

- biological is removal and it is only used for wastewater  
ex: oxidation pond and sludge treatment

iii) MCL and MCLG is the amount of substance allowed in a public water system, MCL is required by law to have and MCLG is the goal to reach.

Surface water treatment rule requires water systems to filter and disinfect surface water sources.

iv) A public water supply system and a pipe network for distributing treated water. Factors affecting it include; sedimentation, runoff, erosion, PH and more.

## Problem 2

$$P = 63000$$

$$r = 8.5\%$$

$$n = 2$$

$$P_{20 \text{ years}} = P_0 (1+r)^n$$

$$= 63000 \left(1 + \frac{8.5}{100}\right)^2 = 74165.175 = \boxed{74166} \checkmark$$

$$\text{average daily demand} = 425 \times 74165 \checkmark$$

$$= \boxed{31.52 \times 10^6 \text{ L/day}}$$

$$\text{fire demand, } Q = 4637 \sqrt{P} (1 - 0.001 \sqrt{P})$$

$$= 4637 \sqrt{74166} (1 - 0.001 \sqrt{74166})$$

$$= 36494.62 \text{ L/min}$$

$$= \boxed{52.55 \text{ m/d}} \times$$

$$\text{maximum daily demand} = 1.8 (31.52 \times 10^6) = \boxed{5.67 \times 10^7 \text{ L/d}}$$

$$\text{maximum weekly demand} = 1.4 (31.52 \times 10^6) = 4.41 \times 10^7 \text{ L/d}$$

$$\text{maximum monthly demand} = 1.2 (31.52 \times 10^6) = 3.78 \times 10^7 \text{ L/d}$$

$$\text{maximum yearly demand} = (31.52 \times 10^6) \text{ L/d} \times \frac{365 \text{ day}}{1 \text{ y}} = 1.15 \times 10^{10} \text{ L/yr} \checkmark$$

$$Q_{\text{total}} = \text{max daily demand} + \text{fire demand}$$

$$= 56.7 \text{ MLD} + 52.55 \text{ m/d} = \boxed{109.25 \text{ MLD}} \times$$

$$\text{Annual} = 31,520 \text{ m}^3/\text{d} \times 365 \text{ d/year} = 11.5 \text{ Mm}^3/\text{year} = 11,504,800 \text{ m}^3/\text{year}$$

$$Q_{\text{fire}} = 3.86 (74.2)^{1/2} * (1 - 0.01(74.2)^{1/2}) = 30.39 \text{ m}^3/\text{min}$$

$$Q_{\text{fire}} = 30.39 \text{ m}^3/\text{min} * 1440 \text{ min/d} = 43,755 \text{ m}^3/\text{d}$$

$$\text{Capacity} = 2.7 * 31,520 + 43,755 = 128,859 \text{ m}^3/\text{d}$$

### Problem 3

$$Q_f = 320 C \sqrt{A} \text{ (m}^3\text{)}$$

$$Q_f = 320 \times 1.5 \sqrt{162000} = 193196.27 \text{ m}^3/\text{d} \times \frac{1 \text{ gal}}{.00379 \text{ m}^3} = 5.1 \times 10^7 \text{ gal/day}$$

$$Q_f = 320 \times 1.5 \sqrt{95000} = 98630.62 \text{ m}^3/\text{d} \times \frac{1 \text{ gal}}{.00379 \text{ m}^3} = 2.6 \times 10^7 \text{ gal/day}$$

$$Q_f = 320 \times 0.8 \sqrt{128200} = 91660.87 \text{ m}^3/\text{d} \times \frac{1 \text{ gal}}{.00379 \text{ m}^3} = 2.4 \times 10^7 \text{ gal/day}$$

$$Q_f = 320 \times 0.6 \sqrt{119000} = 66233.04 \text{ m}^3/\text{d} \times \frac{1 \text{ gal}}{.00379 \text{ m}^3} = 1.7 \times 10^7 \text{ gal/day}$$

$$\text{Total fire demand} = 449720.8 \text{ m}^3/\text{d} = 11.8 \times 10^7 \text{ gal/day}$$

## Problem 4

Given:  $\theta = 3 \text{ hr}$   
 $\text{OFR} = 50 \text{ m}^3/\text{m}^2 \cdot \text{d}$   
 $L = 4W$   
 $A = 8000 \text{ m}^2$   
 $\text{Pop} = 250,000$

$$Q_{\text{avg}} = \text{Pop} \times \text{per capita per day} \\ = 250000 \times 450 \text{ L/capita} \times \frac{\text{m}^3}{1000\text{L}} \\ = 112500 \text{ m}^3/\text{d} \checkmark$$

$$Q_{\text{design}} = 1.4 \times 112500 = 157500 \text{ m}^3/\text{d} \checkmark$$

$$A_{\text{req}} = \frac{Q}{\text{OFR}} = \frac{157500 \text{ m}^3/\text{d}}{50 \text{ m}^3/\text{m}^2 \cdot \text{d}} = 3150 \text{ m}^2$$

$$V = Q \times \theta = 157500 \text{ m}^3/\text{d} \times 3 \text{ hr} \times \frac{1 \text{ d}}{24 \text{ hr}} = 19687.5 \text{ m}^3 \checkmark$$

$$3150 \text{ m}^2 = 4w \cdot w \Rightarrow \boxed{w = 28.06 \text{ m}} \checkmark \\ \boxed{L = 112.24 \text{ m}} \checkmark$$

$$V = L \times w \times D \Rightarrow 19687.5 \text{ m}^3 = 112.24 \times 28.06 \times D \\ \Rightarrow \boxed{D = 6.25 \text{ m}} \checkmark$$

$$\text{horizontal flow} = \frac{Q}{d \times w} = \frac{157500}{6.25 \times 28.06} = \boxed{898.07 \text{ m/d}} \checkmark \\ d = \frac{V}{A} = 6.25 \text{ m}$$

## Problem 5

$$\text{Solids loading} = Q \cdot C = 15000 \text{ m}^3/\text{d} \times 220 \text{ mg/L} \times \frac{1 \text{ kg}}{10^6 \text{ mg}} \times \frac{1000 \text{ L}}{1 \text{ m}^3} = \boxed{3300 \text{ kg/d}} \checkmark$$

$$\text{BOD loading} = Q \cdot C = 15000 \text{ m}^3/\text{d} \times 260 \text{ mg/L} \times \frac{1 \text{ kg}}{10^6 \text{ mg}} \times \frac{1000 \text{ L}}{1 \text{ m}^3} = \boxed{3900 \text{ kg/d}} \checkmark$$

$$\text{Solids loading rate} = \frac{SL}{A} = \frac{3300 \text{ kg/d}}{\frac{\pi}{4} 36^2} = \boxed{3.24 \text{ kg/d-m}^2} \checkmark$$

$$\text{hydraulic loading rate} = \frac{Q}{A} = \frac{15000 \text{ m}^3/\text{d}}{\frac{\pi}{4} 36^2} = \boxed{14.7 \text{ m}^3/\text{d-m}^2} \checkmark$$

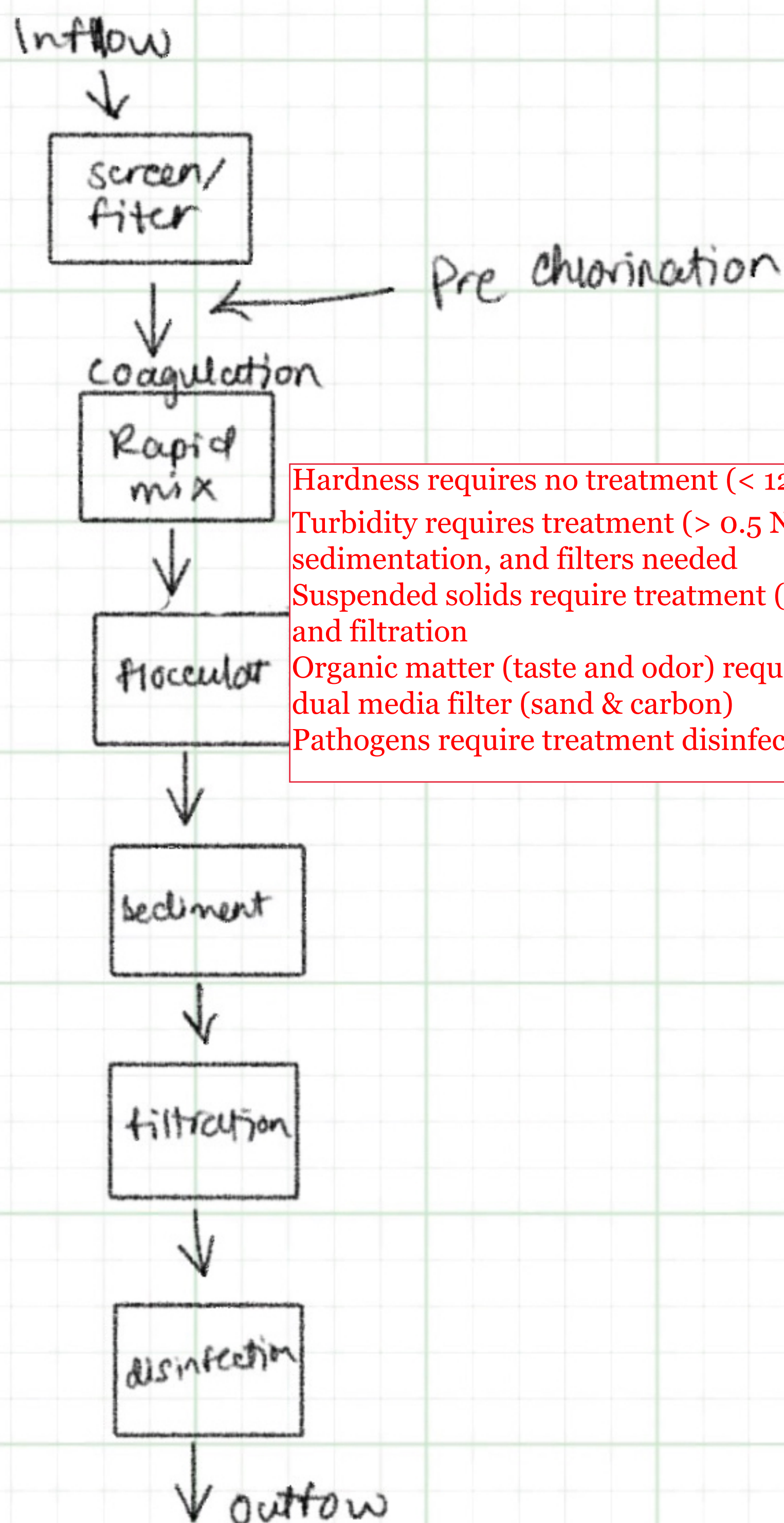
## Problem 6

Hardness = 75 mg/L as  $\text{CaCO}_3$  → no treatment needed because level is acceptable and not a primary standard ✓

Turbidity = 8 NTU → needs to be treated because it is above 0.5 NTU ✓  
can be solved by coagulation

Taste will leave with pre-chlorination and when organic matter is lowered. ✓

SS = 40 mg/L → should be lower and can be removed with filtration ✓



Hardness requires no treatment ( $< 120$  to  $150$  mg/L of  $\text{CaCO}_3$ )

Turbidity requires treatment ( $> 0.5$  NTU) coagulation, flocculation, sedimentation, and filters needed

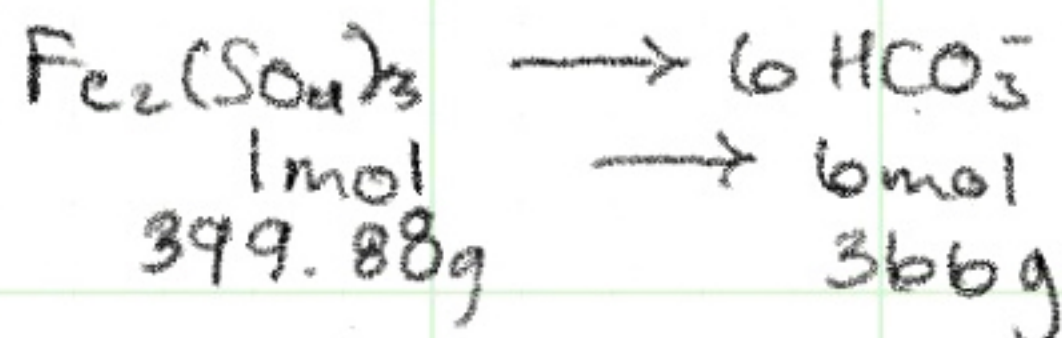
Suspended solids require treatment (40 mg/L is high) sedimentation and filtration

Organic matter (taste and odor) requires treatment carbon absorption, dual media filter (sand & carbon)

Pathogens require treatment disinfection

# Problem 7

Alkalinity



$$50 \text{ mg/L} \times \frac{366 \text{ g}}{399.88 \text{ g}} = 45.76 \text{ mg/L} \times \frac{50 \text{ g as CaCO}_3}{61 \text{ g as HCO}_3^-} = 37.51 \text{ mg/L} \text{ Alk required}$$

Alk is 20 mg/L ✓

37.51 mg/L is needed → not enough alkalinity present

366g alkalinity neutralizes 399.88g of ferric sulfate

$$\frac{399.88 \text{ g}}{366 \text{ g}} \times 20 \text{ mg/L} = 21.85 \text{ mg/L}$$

ferric sulfate that needs to be neutralized after alkalinity:  
 $50 \text{ mg/L} - 21.85 \text{ mg/L} = 28.15 \text{ mg/L}$  ✓

Water is neutralized by adding lime

## Problem 8

$$i) \frac{40 \text{ mg/L} (12500 \text{ m}^3/\text{d})}{.80} \times \frac{1000 \text{ L}}{1 \text{ m}^3} \times \frac{16 \text{ g}}{10^6 \text{ mg}} \times \frac{315}{100 \text{ kg}} \times \frac{365 \text{ d}}{1 \text{ y}}$$

$$= \boxed{718593.75 \text{ /year}}$$

ii) 1 mol Alum needs 2 mol  $\text{Al}(\text{OH})_3$

342 g

156 g

$$40 \text{ mg/L Alum} \times \frac{156 \text{ g Al}(\text{OH})_3}{342 \text{ g Alum}} = 18.25 \text{ mg/L Al}(\text{OH})_3$$

$$\text{Floc} = 18.25 \text{ mg/L} \times 12500 \text{ m}^3/\text{d} \times \frac{1000 \text{ L}}{\text{m}^3} \times \frac{1 \text{ kg}}{10^6 \text{ mg}} = \boxed{228.13 \text{ kg/d}}$$

$$\text{Total solids} = [(.85 \times 25) + 18.25] \text{ mg/L} \times 12500 \text{ m}^3/\text{d} \times \frac{1000 \text{ L}}{\text{m}^3} \times \frac{1 \text{ kg}}{10^6 \text{ mg}}$$

$$= \boxed{493.75 \text{ kg/d}}$$

**CVEG 4301– Environmental Engineering Design  
Fall 2021**

**Instructor: Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE**

**Title of Assignment**

Design of Water Treatment Plant

**Outcome Measured Using this Assignment**

**Outcome 2**

**n ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors**

**Brief Description of the suitability of this assignment for the outcome**

In this project, the students need to design various components of a water treatment plant. The students need to analyze the problem and review literature and design the components. 300 points out of 500 points are given for the design aspects (criteria “2”) and 200 points for solving complex engineering problems (Criteria “1”)

Prairie View A&M University  
Roy G. Perry College of Engineering  
Civil & Environmental Engineering Department

SLO 1: 180/200

SLO 2: 270/300



**CVEG 4301: Environmental Engineering Design**

**Title: Water Treatment Plant Design**

**Submitted By:**

**Abram Auguste**

**Michael LeBlanc**

**Submitted To: Dr. Kommalapati, Rhagva**

**Issue Date: October 28, 2021**

**Due Date: December 5, 2020 11:59 p.m.**

some design numbers like floc basins,  
sed tanks (50) are not realistic and  
should have thought through  
you conduct jar test to find Alum  
dosage not use alkalinity

## **Letter of Transmittal**

December 5, 2021

Dr. Raghava Kommalapati, PhD, PE, BCEE, F.ASCE

Civil Engineering Department

Roy G. Perry Engineering Building

Prairie View A&M University

Dear Dr. Kommalapati:

The attached technical design report contains the preliminary data and background information needed to start the design of the City of Austin, Texas, water treatment plant. The design period for the city is twenty (20) years and the project will be carried out in two stages. Constraints of the report were issued in-class on September 30, 2021. The report contains the abstract, introduction, summary, the equations used for analysis of the data, the raw experimental data, tabulated presentation of the important results, discussion, interpretation of the results, and recommendations. Please contact me at 857-342-0981 or by email at [aauguste@pvamu.edu](mailto:aauguste@pvamu.edu) if you have any questions or concerns regarding the report.

Sincerely,

Abram Auguste

Michael LeBlanc

## **TABLE OF CONTENTS**

|                                   |    |
|-----------------------------------|----|
| ABSTRACT.....                     | 4  |
| LIST OF FIGURES/TABLES.....       | 5  |
| CHAPTER 1: Population .....       | 6  |
| 1.1 Arithmetic Method.....        | 6  |
| 1.2 Geometric Method.....         | 8  |
| CHAPTER 2: Water Demand .....     | 10 |
| 2.1 Fire Demand:.....             | 11 |
| 2.1 Water Acquisition:.....       | 12 |
| CHAPTER 3: Water Quality.....     | 15 |
| 3.1 Water Treatment Plant:.....   | 19 |
| 3.2 Water Treatment Diagram:..... | 20 |
| 3.3 Screening:.....               | 21 |
| 3.4 Rapid Mixing:.....            | 21 |
| 3.5 Floc Production:.....         | 27 |
| 3.6 Flocculation Tank:.....       | 28 |
| 3.7 Sedimentation Tank:.....      | 30 |
| 3.8 Filtration:.....              | 32 |
| 3.9 Storage:.....                 | 36 |
| References .....                  | 37 |
| Appendix .....                    | 22 |

## **List of Figures**

|                                                                     |    |
|---------------------------------------------------------------------|----|
| Table 1 “Population Estimated Growth for 2040” .....                | 6  |
| Figure 1: “Population Growth shown through Arithmetic Method” ..... | 8  |
| Table 2a. “Pros and Cons of Water Sources” .....                    | 12 |
| Table 2b. “LCRA Water Quality Data” .....                           | 12 |
| Table 3. “Water Quality for Lower Colorado River” .....             | 15 |
| Figure 2: “Layout of Water Treatment Plant” .....                   | 19 |

# Austin Water Design

## Abstract

include a separate page with  
executive summary not abstract that  
highlights all the salient features of  
your design

Austin, Texas is the designated location for the water treatment plant. The city has a 20-year planning period with the arithmetic method being the point of reference for the future population projection. The design purposes the water source is the Colorado River which is regulated by the Lower Colorado River Authority. In devising for the water treatment design, a water quality report was assessed where turbidity, hardness, and microorganism levels were high. Potentially a consequence of erosion and Sewage runoff. The design is executed pursuant to the Texas Administrative Code, National Primary Drinking Water Regulations, and Surface Water Treatment Rules. The information provided herein the report is an essential antecedent for the development of a fully functional municipal water treatment plant.

## Water Sources

The city of Austin, Texas, contains multiple surface water sources including but not limited to the Lower Colorado River as it flows through Lake Travis, and Lake Austin, Inks Lake, and Lake Marbles Falls. For the purpose of this design project, we will focus on the Colorado River. The Colorado River has long been a life source for indigenous tribes of Texas, such as the Comanches. Modifications to the lower river began in the 1930s and 40s in order to manage to flood and generate hydroelectric power. Furthermore, Austin draws all its drinking water from one source, the Colorado River. To be precise, river water is pulled from Lake Travis

and Lake Austin, which are both part of the seven-member Highland Lakes system. In addition to the Colorado river being the optimum choice, the team also considered the city’s prepaid \$100 million to the Lower Colorado River Authority to guarantee water to Austin from the river through at least 2050. The authority manages a 600-mile stretch of the Colorado River in Texas and the Highland Lakes by Austin.

## 1. Population

The population growth for Austin was calculated for 2040 because the design period for both water and wastewater treatment facilities is 20 years. To estimate the population and forecast future water use, various methods can be utilized. The arithmetic technique, uniform percentage method, curvilinear approach, logistic method, and ratio method are all ways that can be used to predict future population.

### 1.1 Arithmetic Method

The Arithmetic Method is a technique used to populate the estimation of the future population with a constant growth rate. Table 1 displays the population and change for each decade.

**Table 1. Population Estimated Growth for 2040**

| Year | Population | $\Delta$ Population | $\frac{\Delta P}{P}$ | % Increase |
|------|------------|---------------------|----------------------|------------|
| 1950 | 132,459    | -                   | 0                    | -          |
| 1960 | 186,545    | 54,086              | .29                  | 29%        |
| 1970 | 251,808    | 65,263              | .26                  | 26%        |

|         |         |          |      |     |
|---------|---------|----------|------|-----|
| 1980    | 345,890 | 94,082   | .27  | 27% |
| 1990    | 465,422 | 119,532  | .26  | 26% |
| 2000    | 656,562 | 191,140  | .18  | 18% |
| 2010    | 790,390 | 133,828  | .17  | 17% |
| 2020    | 961,855 | 171,465  | .18  | 18% |
| Total   |         | 829,396  | 1.61 | 161 |
| Average |         | 106674.5 | .20  | 20% |

The future population estimation is determined by using the following arithmetic equation,

$$P_f = P_o + k (\Delta t)$$

$P_f$  = Population at time (t)

$P_o$  = Population at time (zero)

$k = \frac{dp}{dt}$ , growth rate

t = elapsed time in years (decades)

The population growth rate (k) was calculated by dividing the total amount of population change from Table 1 by the time. The following equation was used to calculate Austin's population in 2041.

$$k = \frac{829,396}{8} = 103,674$$

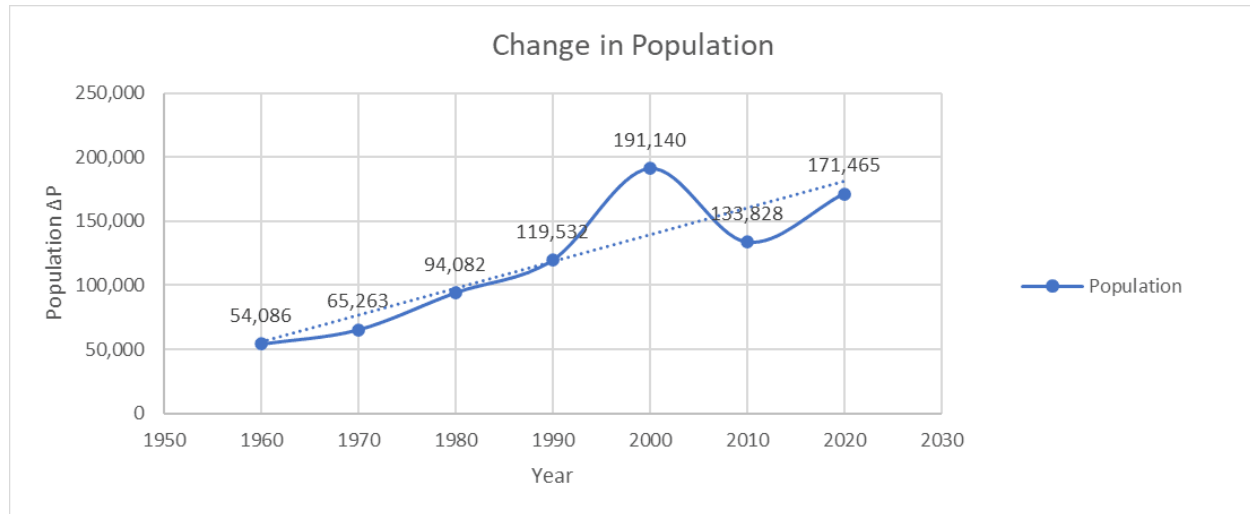
$$P_f = 961,855 + (103,674)(2)$$

$$P_f = 1,116,203 \text{ persons}$$

Austin is predicted to have a population of roughly 1,119,358 people in 2040. Figure 2 depicts Austin's population growth over the next 50 years. Because the data in Figure 1 demonstrates that the population is increasing, the Arithmetic Method was used to predict the water demand

for 2040. The arithmetic approach is a crucial method, as evidenced by the graph because the population rate increases then start to decrease as you approach the current time.

**Figure 1: Population Growth shown through Arithmetic Method**



The arithmetic method describes the multiple variations of the population from 1950 to 2020.

The Arithmetic method isn't the most accurate method so the Geometric method which is more precise was taken.

The geometric method, commonly known as the uniform percentage method, uses the following equation to estimate the expected population:

$$\ln P = \ln P_o + K' \Delta t$$

Where

$P$  = Future Population in persons

$P_o$  = Current Population in persons

$K'$  = Growth Rate Percentage

$t$  = Number of Decades

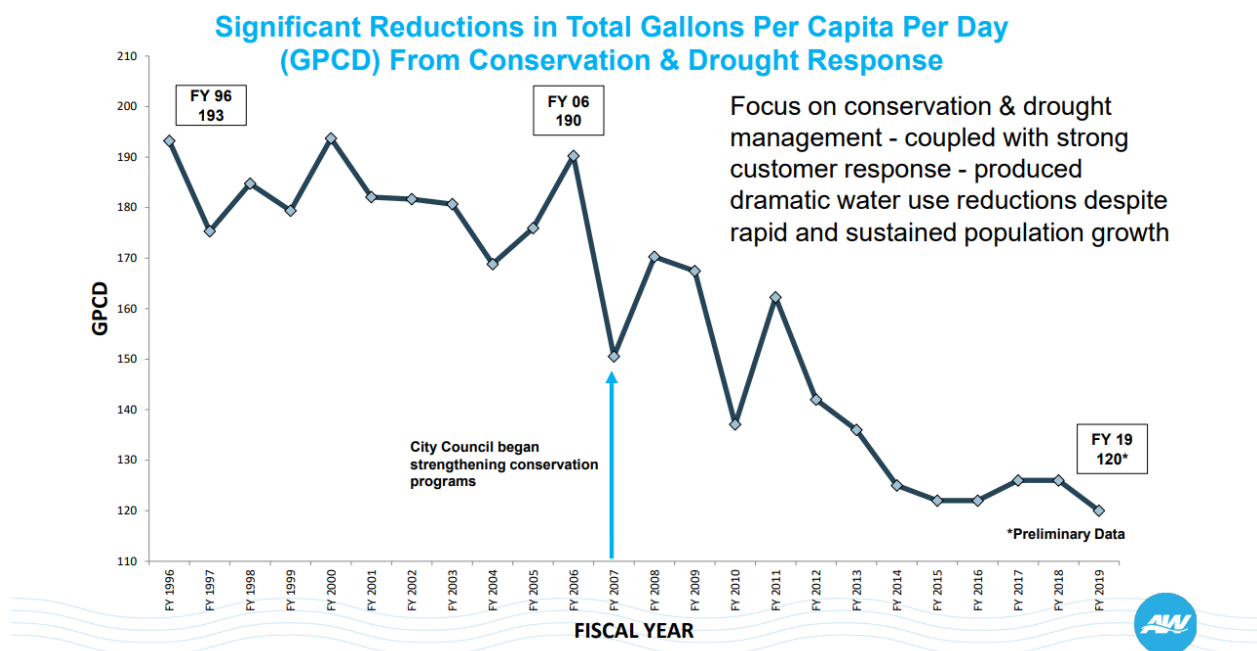
$$P = P_o e^{K' \Delta t}$$

$$P_{20} = 961,855e^{.2(2)}$$

$$P_{20} = 1,434,919 \text{ persons}$$

The geometric method was used in place of the arithmetic method because of its accuracy. The estimated population is 1,434,119 and compared to Austin's estimated future population of 1,301,409 which is slightly over Austin's projection. This happened because our percent growth was .2 and the city used a percent growth of 1.5%.

ok good.



**Figure 2: Austin's flat line of gallons per capita day**

For the last eight to nine years the City of Austin has supplied water in the approximate range of 120 gallons per capita per day. The chart suggests a downward trend resulting from the city's conservation and drought management plan. For design purposes, 120 gpcd will be utilized.

ok

## 2. WATER DEMAND

It is necessary to have a fair understanding and characterization of how and where water is being used in Austin, as well as measurable predictions of how much water will be needed in the future, to appropriately plan and manage Austin's water resources. Water demand is determined by the amount of water consumed and the area's requirements. The estimated population for the year 2040 will determine water use. 1,434,919 people are predicted to live in 2040. The population will enable the average daily flow per capita to be calculated. The maximum values for water consumption hourly, daily, and yearly were computed for the design of storage facilities for the city of Austin's water treatment plan. To determine the total maximum water demand for the city of Austin in relation to the proposed water treatment facilities it was determined that the Water produced plus the water stored totaled the water demand. Also, by observing the per capita water demand data issued by the city of Austin, the general trend indicates that by the year 2040 the per capita water demand will be about 120 gpcd [1]. Assume that the demand remains constant at about 120 gal/capita-day. In addition, Pursuant to 30 TAC §290.38(46), in the absence of verified historical data or in cases where a public water system has imposed mandatory water use restrictions within the past 36 months, peak daily demand means 2.4 times the average daily demand of the system. Pursuant to 30 TAC §290.38(60), Peak hourly demand--In the absence of verified historical data, peak hourly demand means 1.25 times the maximum daily demand (prorated to an hourly rate) if a public water supply meets the commission's minimum requirements for elevated storage capacity and

1.8 times the maximum daily demand (prorated to an hourly rate) if the system uses pressure tanks or fails to meet the commission's minimum elevated storage capacity requirement. [2]

$$Q_{2040} = (120 \text{ gpcd})(\text{future population at design year}, P_{2040})$$

$$= (120 \text{ gpcd})(1,434,919) = 172,190,280 \text{ gpd} = 1.72 \times 10^8 \text{ gpd} = 172 \text{ MGD}$$

- Maximum Hourly

$$Q_{\text{Hourly}} = Q_{2040} \times DF = (172 \text{ MGD}) \times (2.4) = 412.6 \text{ MGD}$$

- Maximum Daily

$$Q_{\text{Daily}} = Q_{2040} \times DF = (172 \text{ MGD}) \times (1.8) = 309.6 \text{ MGD}$$

- Maximum Weekly

$$Q_{\text{Weekly}} = Q_{2040} \times DF = (172 \text{ MGD}) \times (1.4) = 240.8 \text{ MGD}$$

Maximum Monthly

$$Q_{\text{Monthly}} = Q_{2040} \times DF = (172 \text{ MGD}) \times (1.2) = 206.4 \text{ MGD}$$

## 2.1 FIRE DEMAND

Public Services demand water for public buildings, cleaning streets, parks, and fire protection. The water used for firefighting is a small fraction of the overall water demand; the short-term demand rate is high and dictates pipe sizes in small systems. The design project will utilize the Insurance Services Office (ISO) formula below:

$$Q_{g.p.m.} = 1020\sqrt{P} \times (1 - 0.1 \times \sqrt{P}) \quad (1)$$

Where P= Population of a water district in thousands of people

Q= Necessary fire flows in gallons per minute.

Therefore,

$$Q_{F.D.} = 1020\sqrt{1,434.919} \times (1 - 0.1 \times \sqrt{1,434.919}) = 24,001.76 \frac{\text{gal}}{\text{min}} \times \frac{60 \text{ min}}{1 \text{ hour}} \times \frac{24 \text{ hours}}{1 \text{ day}}$$

$$= 34,562,534.4 \frac{\text{gal}}{\text{day}} = \mathbf{34.6 \text{ MGD}}$$

In order to estimate the total maximum water demand if you're incorporating the distribution system for the city of Austin for the Water treatment facilities, the team summed the consumption flow with the fire protection flow. The total maximum water demand for 2040 would be given by:

$$Q_{Total} = Q_{Hourly} + Q_{F.D.}$$

$$= 172,190,280 \frac{\text{gal}}{\text{day}} + 1.8 \times \left( \frac{1 \text{ day}}{1440 \text{ min}} \right) + 34,504,534.4 \frac{\text{gal}}{\text{day}} (1 \text{ day} \cdot 1440 \text{ min}) =$$

$$310,945.282 \text{ gpm}$$

Since we are not taking into consideration the distribution piping system for this design the flow should be calculated as  $Q_{Total} = Q_{Daily}$  and from here we pick  $Q_{Daily}$  as our design flow for 2040.

$$Q_{Total} = Q_{Daily}$$

$$Q_{Total} = (172 \text{ MGD})(1.8) = \mathbf{309.9 \text{ MGD}}$$

high but ok

## 2.2 Acquisition of Water

Austin has 5 water sources the state uses for water supply. Lake Travis, Lake Buchanan, Lake Austin, Lake Lyndon B. Johnson, and The lower part of the Colorado river. Austin's drinking water comes entirely from the Colorado River's lower reaches. The lower Colorado River is the part of the river that runs between Lakes O.H. Ivie and Brownwood to the Gulf of

Mexico. The Highland Lakes were formed by damming the lower Colorado River numerous times upstream from Austin. Lake Buchanan and Lake Travis, two of the Highland Lakes, serve as the region's water supply and flood control reservoirs. It can be assumed that Austin, Tx gets 100% of its water from surface water because all of the water supply comes from the lower part of the Colorado River.

**Table 2a. Pros and Cons of Water Sources (According to Water Quality)**

| Source Of Water        | Pros                                                                                            | Cons                                       |
|------------------------|-------------------------------------------------------------------------------------------------|--------------------------------------------|
| Lake Travis            | Low Turbidity                                                                                   | Cryptosporidium (May be harmful to humans) |
| Lake Austin            | Low Turbidity                                                                                   | Cryptosporidium (May be harmful to humans) |
| Lake Lyndon B. Johnson | Low Turbidity                                                                                   | Not main source of water source, location  |
| Lake Buchanan          | High TS                                                                                         | Location, Low pH,                          |
| Lower Colorado River   | All water sources flow through city, Location, main source of water for the city, Low turbidity | Cryptosporidium (May be harmful to humans) |

### Colorado River Selection

According to the below tables consisting of live data from the Lower Colorado River Association the team analyzed information from the 5 rivers and ultimately determined that the Colorado River would serve the Austin community best. The Colorado River had the highest Dissolved Oxygen (DO) level amongst the 5 rivers. The High DO level is good as it makes drinking water taste better. However, the High DO levels speed up corrosion in water pipes which adds additional expenses to the preservation of the water treatment plant and preserving the pipes. All the rivers have DO levels ranging from 4.35 mg/L to 7.1 mg/L with the Colorado

River having the highest value. Industries prefer to use water with lower DO levels but in our case, we will take the risk for design purposes. Another reason for choosing the Colorado River is because it is in closest proximity to the city of Austin. There will be less expense in transporting water to the local community. Lake Buchanan, LBJ Lake, Lake Travis, and Lake Austin are further away from the city population and could serve as an additional expense. The pH level isn't a quality that falls under EPA regulation because it's considered an aesthetic quality of water. However, the agency recommends that municipal drinking water suppliers keep their water supply at a pH of 6.5 to 8.5. The Colorado River falls within the U.S. Environmental Protection Agency's recommendation. The U.S. Environmental Protection Agency (EPA) standard for nitrate in drinking water is 10 milligrams of nitrate (measured as nitrogen) per liter of drinking water (mg/L). Drinking water with levels of nitrate at or below 10 mg/L is considered safe for everyone. In our instance the Colorado River meets such requirements. The water Flow is also highest with the Colorado River thus reducing the cost for pumps as compared with the other rivers.

**Table 2b. LCRA Water Quality Data**

SITE: 329

Colorado River at Montopolis Bridge

Hydromet Rainfall

Graph Data

Images

Hydromet Flow

| Date     | Time  | Air Temp (C) | Water Temp (C) | Flow | pH  | GTLT | Nitrates-N (mg/L) | DO Avg (mg/L) | DO % Sat | Cond (µS/cm) | Days Since Rain | Field Rain Gauge (in.) | GTLT | Secchi (M) | GTLT | Transparency (M) | E.coli (cfu's) |
|----------|-------|--------------|----------------|------|-----|------|-------------------|---------------|----------|--------------|-----------------|------------------------|------|------------|------|------------------|----------------|
| 4/5/2021 | 12:04 | 25           | 20             | 4    | 7.9 | <    | 1                 | 7.1           | 78.1     | 520          | 1               |                        |      |            | =    | 0.53             |                |

SITE: 27

Lake Austin below Mansfield Dam

Hydromet Rainfall

Graph Data

Images

| Date       | Time  | Air Temp (C) | Water Temp (C) | Flow | pH | GTLT | Nitrates-N (mg/L) | DO Avg (mg/L) | DO % Sat | Cond (µS/cm) | Days Since Rain | Field Rain Gauge (in.) | GTLT | Secchi (M) | GTLT | Transparency (M) | E.coli (cfu's) |
|------------|-------|--------------|----------------|------|----|------|-------------------|---------------|----------|--------------|-----------------|------------------------|------|------------|------|------------------|----------------|
| 10/25/2021 | 14:00 | 29.5         | 18             | 1    | 7  | <    | 2                 | 4.35          | 46.11    | 500          | 11              | 0                      |      |            |      |                  |                |

SITE: 22

Lake Travis at Lakeway Marina

Hydromet Rainfall

Graph Data

| Date      | Time  | Air Temp (C) | Water Temp (C) | Flow | pH  | GTLT | Nitrates-N (mg/L) | DO Avg (mg/L) | DO % Sat | Cond (µS/cm) | Days Since Rain | Field Rain Gauge (in.) | GTLT | Secchi (M) | GTLT | Transparency (M) | E.coli (cfu's) |
|-----------|-------|--------------|----------------|------|-----|------|-------------------|---------------|----------|--------------|-----------------|------------------------|------|------------|------|------------------|----------------|
| 8/29/2021 | 12:05 | 27.5         | 28             | 3    | 7.5 | <    | 1                 | 6.8           | 85.68    | 450          | 0               |                        | >    | 3.5        |      |                  |                |

| SITE: 441<br>Lake Buchanan at Cassies |       |                 |                   |      |    |      |                      |                  |             |                 |                    |                           | Hydromet Rainfall<br>Graph Data<br>Images |               |      |                     |                   |
|---------------------------------------|-------|-----------------|-------------------|------|----|------|----------------------|------------------|-------------|-----------------|--------------------|---------------------------|-------------------------------------------|---------------|------|---------------------|-------------------|
| Date                                  | Time  | Air Temp<br>(C) | Water Temp<br>(C) | Flow | pH | GTLT | Nitrates-N<br>(mg/L) | DO Avg<br>(mg/L) | DO %<br>Sat | Cond<br>(µS/cm) | Days Since<br>Rain | Field Rain<br>Gauge (in.) | GTLT                                      | Secchi<br>(M) | GTLT | Transparency<br>(M) | E.coli<br>(cfu/s) |
| 12/28/2019                            | 15:30 | 17.8            | 18                | 2    | 7  |      |                      | 7                | 74.2        | 420             | 18                 | 0.6                       |                                           |               |      |                     |                   |

| SITE: 464<br>Lake LBJ at West Ranch |       |                 |                   |      |      |      |                      |                  |             |                 |                    |                           | Hydromet Rainfall<br>Graph Data |               |      |                     |                   |
|-------------------------------------|-------|-----------------|-------------------|------|------|------|----------------------|------------------|-------------|-----------------|--------------------|---------------------------|---------------------------------|---------------|------|---------------------|-------------------|
| Date                                | Time  | Air Temp<br>(C) | Water Temp<br>(C) | Flow | pH   | GTLT | Nitrates-N<br>(mg/L) | DO Avg<br>(mg/L) | DO %<br>Sat | Cond<br>(µS/cm) | Days Since<br>Rain | Field Rain<br>Gauge (in.) | GTLT                            | Secchi<br>(M) | GTLT | Transparency<br>(M) | E.coli<br>(cfu/s) |
| 10/13/2021                          | 11:41 | 28.9            | 25.6              | 2    | 7.54 |      |                      | 5.18             | 62.78       | 481             | 12                 | 0.25                      | >                               | 1.45          |      |                     |                   |

### 3.1 Water Quality

Austin's drinking water is supplied by three water treatment plants that pump surface water from the Lower Colorado River as it flows into Lake Travis and Lake Austin. To remove any potentially dangerous contaminants, the City of Austin purifies and filters the water according to federal and state requirements. Many miles upstream, the Lower Colorado River's watershed passes through agricultural and urban areas. The Lower Colorado River is the water source that passes through the majority of the water sources listed above and is the main source of drinking water. The water quality for the Lower Colorado River is shown below.

**Table 3.1 Water Quality for Lower Colorado River**

| Constituent     | Concentration |
|-----------------|---------------|
| Calcium         | 48 (mg/L)     |
| Magnesium       | 19 (mg/L)     |
| pH (units)      | 8             |
| Turbidity (NTU) | 1.61          |
| E.Coli          | 1             |
| Total Phosphate | <0.05         |

|                                          |                     |
|------------------------------------------|---------------------|
| Total Alkalinity (as CaCO <sub>3</sub> ) | 169 (mg/L)          |
| Total Solids                             | 340 (mg/L)          |
| Total Hardness ( as CaCO <sub>3</sub> )  | 200 (mg/L)          |
| Total Coliform ( Col/100ml)              | 20                  |
| Capacity                                 | 2,663,086 (acre-ft) |

**Table 3.2 Water Quality for Lake Austin**

| <b>Constituent</b>                       | <b>Concentration</b> |
|------------------------------------------|----------------------|
| Calcium                                  | 12.43 (mg/L)         |
| Aluminium                                | <0.02                |
| Bicarbonate                              | 39 (ppm)             |
| Turbidity (NTU)                          | 0.13                 |
| Sodium                                   | 21.96 (mg/L)         |
| Carbonate                                | 19.66 (mg/L)         |
| Total Alkalinity (as CaCO <sub>3</sub> ) | 154 (mg/L)           |
| Total Dissolved Solids                   | 166 (mg/L)           |
| Total Hardness ( as CaCO <sub>3</sub> )  | 94.2 (mg/L)          |
| Fluoride                                 | 0.73 (mg/L)          |
| Capacity                                 | 23,597 (acre-ft)     |

**Table 3.3 Water Quality for Lake Travis**

| <b>Constituent</b> | <b>Concentration</b> |
|--------------------|----------------------|
| Calcium            | 40.3 (mg/L)          |

|                                          |                   |
|------------------------------------------|-------------------|
| Magnesium                                | 19.75 (mg/L)      |
| pH (units)                               | 7.78              |
| Turbidity (NTU)                          | 0.022             |
| Potassium                                | 19.75 (ppm)       |
| Sodium                                   | 22.8 (ppm)        |
| Total Alkalinity (as CaCO <sub>3</sub> ) | 169               |
| Total Dissolved Solids                   | 267.5 (ppm)       |
| Sulfate                                  | 25.5              |
| Hardness                                 | 188.65 (ppm)      |
| Capacity                                 | 819,165 (acre-ft) |

**Table 3.4 Water Quality for Lake Buchannon**

| <b>Constituent</b>         | <b>Concentration</b>    |
|----------------------------|-------------------------|
| Barium                     | .091 (ppm)              |
| Nitrate                    | .25 (ppm)               |
| Fluoride                   | .17 (ppm)               |
| Turbidity (NTU)            | .31                     |
| Sodium                     | 29.4 (ppm)              |
| Hardness                   | 173 (ppm) or 10.1 (gpg) |
| Chloroform                 | 5.3                     |
| Bromodichloromethane (ppb) | 13 (ppb)                |
| Dibromochloromethane (ppb) | 16 (ppb)                |
| Capacity                   | 772,928 (acre-ft)       |

**Table 3.5 Water Quality for Lake Lydon B Johnson**

| <b>Constituent</b>                  | <b>Concentration</b> |
|-------------------------------------|----------------------|
| Copper                              | 1.3 (ppm)            |
| Lead                                | 15 (ppb)             |
| Chloride                            | 50 (mg/L)            |
| Manganese                           | .0050 (mg/L)         |
| Total Alkalinity                    | 156 (mg/L)           |
| Total Dissolved Solids              | 294 (mg/L)           |
| Total Hardness as Calcium Carbonate | 195 (mg/L)           |
| Zinc                                | .0056 (mg/L)         |
| Barium                              | .0738 (ppm)          |
| Carbon                              | 4.96 (mg/L)          |
| Capacity                            | 131,365 (acre-ft)    |

**FLOW PROCESS & Layout Plans**

The following Laws were used in this project and taken into consideration for designing the treatment plants. “Pursuant to 30 TAC §290.42(d)(9)(A) Plants with a design capacity greater than 3.0 MGD must provide at least two sets of flocculation equipment that are designed to operate in parallel. Plants with a design capacity greater than 3.0 MGD must provide at least two sedimentation basins or clarification units that are designed to operate in parallel. Public water systems with other surface water treatment plants, interconnections with other systems, or wells that can meet the system's average daily demand are exempt from the requirement for redundant sedimentation basins or clarification units. See 30 TAC §290.42(d)(10)(A). In addition, 30 TAC §290.42(e)(3) requires that Disinfection equipment shall be selected and

installed so that continuous and effective disinfection can be secured under all conditions.”

Based on these laws the following layout was developed below:

### 3.2 WATER TREATMENT PLANT

The population size is the factor that will determine the City of Austin’s quantity of demand for water treatment. The water demand for the City of Austin will factor with the maximum daily quantity of water in designing the Water Treatment Plant (WTP).

$$AADF = Population \times Q_{Demand}$$

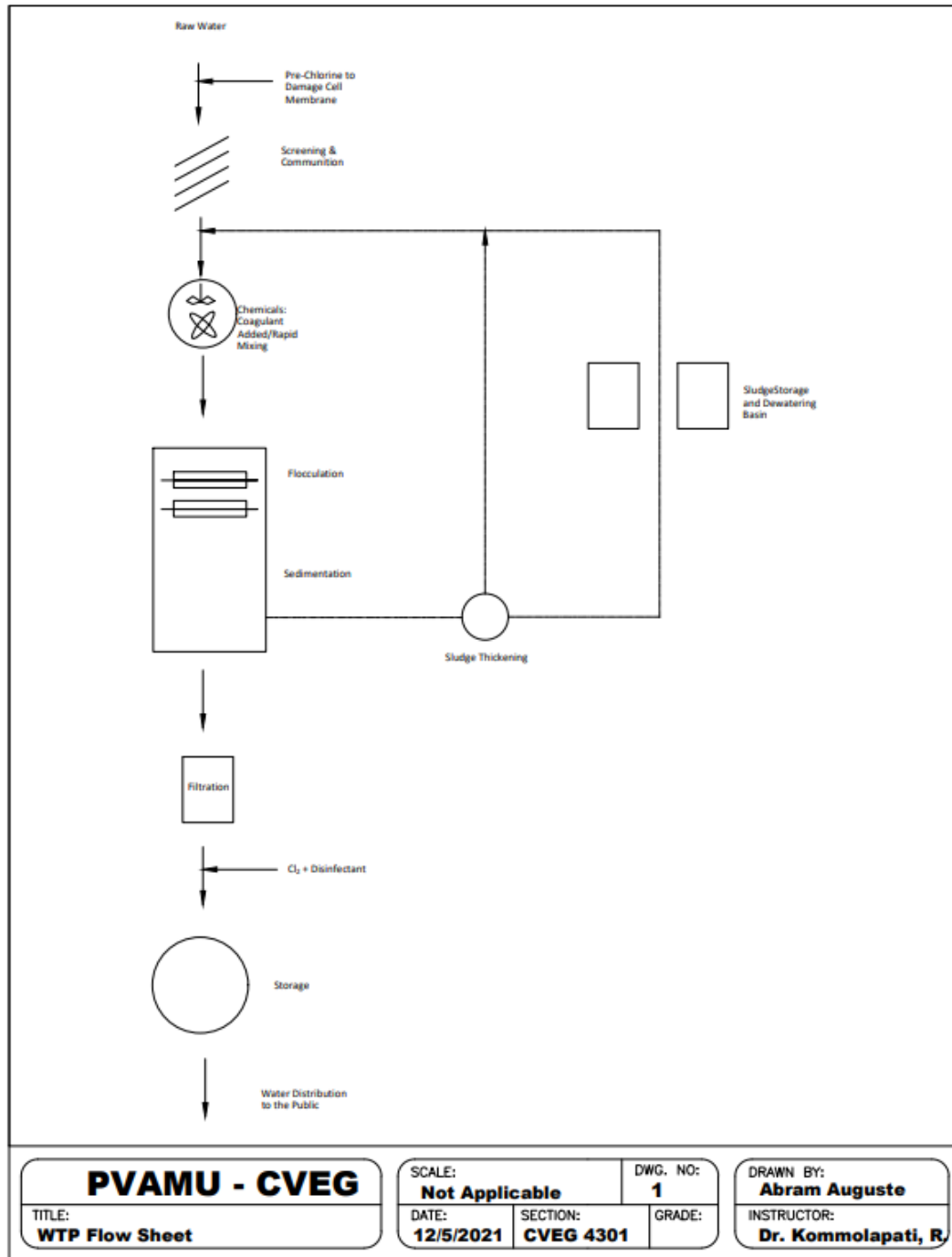
$$1,434,919 \text{ capita} \times 120 \frac{\text{gal}}{\text{capita} \cdot \text{day}} = 172,190,280 \frac{\text{gal}}{\text{day}} = 172 \text{ MGD}$$

$$Q_{Total} = AADF \times Peak \text{ Factor} = 172,190,280 \frac{\text{gal}}{\text{day}} \times 1.8 = 309,942,504 \frac{\text{gal}}{\text{day}} = 309.9 \text{ MGD}$$

Therefore, the total water flow will be in the amount of 309.9 MGD

### **3.3 WATER TREATMENT DIAGRAM**

all formatting is messed up



### 3.4 SCREENING

The screening process applies to Water and Wastewater Treatment. Screening is the first unit operation used at water treatment plants (WTPs). Screening removes objects such as rags, paper, plastics, and metals to prevent damage and clogging of downstream equipment, piping, and appurtenances. Some modern water treatment plants use both coarse screens and fine screens. Screening is a physical process used to eliminate Turbidity and suspended matter which serves as a contaminant for water and wastewater treatment.

1. **Coarse Screens** Coarse screens remove large solids, rags, and debris from wastewater, and typically have openings of 6 mm (0.25 in) or larger. Types of coarse screens include mechanically and manually cleaned bar screens, including trash racks.
2. **Fine Screens** Fine screens are typically used to remove material that may create operation and maintenance problems in downstream processes, particularly in systems that lack primary treatment. Typical opening sizes for fine screens are 1.5 to 6 mm (0.06 to 0.25 in). Very fine screens with openings of 0.2 to 1.5 mm (0.01 to 0.06 in) placed after coarse or fine screens can reduce suspended solids to levels near those achieved by primary clarification.

### **3.5 RAPID MIXING TANK**

The raw water will first enter the rapid mixing tank's chamber for treatment. The Rapid mixing is the process in which chemicals are quickly and uniformly dispersed in water (Instantaneously or a reaction time of 0.1 seconds). The coagulant treatment used will be Alum.

Applying the water demand for the City of Austin the volume can be obtained as a function of detention time by the water flow as seen below.

$$\theta = \frac{Q}{V}$$

Where,

$\theta$  = Detention Time

Q = Water Flow Rate

V = Rapid Mixing Tank Total Volume

Rapid mixing tanks have certain design criteria set by the Texas Administrative Code (TAC). Also, the volume of a rapid-mix tank seldom exceeds  $8 \text{ m}^3$  because of mixing equipment and geometry constraints. For sweep coagulation G values in the range of 600 to 1,000 per second units ( $\text{s}^{-1}$ ) are recommended (Davis & Cornwell, 2013, pg. 301). The detention time for the tank is in the range of twenty (20) to sixty (60) seconds. The above set criteria allows for tank maximization.

$$V = \theta \times Q$$

The calculations of the various detention times versus the different volumes allows for viable options for the projected city population. The sixty (60) second detention time allows for a larger amount of tanks for a population growing at a constant rate when compared to the thirty (30) second detention time. An exception to these time requirements is for color or natural organic matter removal. Rapid mix basins must provide not more than 30 seconds detention time with adequate velocity gradients to keep the lime particles dispersed.<sup>[6]</sup> (Ten State Standard § 4.4.1.4) A reduced detention time avoids the need for aggressive mixing over long periods of time whereas the shorter detention time achieves the same objectives at a reduced cost. For

sweep coagulation, detention times of 1 to 10 s and G values in the range of 600 to 1,000  $s^{-1}$  are recommended. (Davis & Cornwell, 2013, pg. 301). It is found that rapid mix detention times of 2 to 5 minutes at low rapid mix G values of 300 to 700  $s^{-1}$  work best. (Davis & Cornwell, 2013, pg. 301). However, according to the Ten State Standard, when mixing – The detention period should not be more than thirty seconds with mixing equipment capable of imparting a minimum velocity gradient (G) of at least 750 fps/ft. Also, detention time should be in the range of 20-60 sec, can be as low as 20 sec or as long as 5 min (in theory) For practical purposes a velocity gradient of 900  $s^{-1}$  will be used. The design engineer should determine the appropriate G value and detention time through jar testing. Pursuant to Texas Commission on Environmental Quality (Revised Dec. 2019) of §290.42(d)(8)(A) Flash mixing equipment shall be provided. (A) Plants with a design capacity greater than 3.0 million gallons per day (MGD) must provide at least one hydraulic mixing unit or at least two sets of mechanical flash mixing equipment designed to operate in parallel.

$$\begin{aligned}
 Volume &= 309.943 \times 10^6 \frac{gal}{d} \times \frac{3.785 L}{1 gal} \times \frac{1 m^3}{1,000 L} \times 30 sec \times \frac{1 min}{60 sec} \times \frac{1 hr}{60 min} \times \frac{1 d}{24 hr} = \\
 &= 407.34 m^3 > 8 m^3 \\
 &= \frac{45.42 m^3}{8 m^3} = 50.92 \approx 51
 \end{aligned}$$

Since the volume of 407.34  $m^3$  exceeded the suggested criteria.<sup>[5]</sup>, it is determined that there must be a total of fifty-one (51) tanks. The volume of tanks can thus be to their respective eight cubic meters.

not practical but based on our class discussion ok

$$51 tanks \times 8 m^3 = 408 m^3$$

Therefore, the total Volume for 51 tanks is 408  $m^3$

| Detention (sec) | Volume ( $m^3$ ) | Number of Tanks | Volume per Tank | Total Volume |
|-----------------|------------------|-----------------|-----------------|--------------|
| 20              | 271.5588553      | 34              | 7.987           | 272          |
| 30              | 407.338283       | 51              | 7.987           | 408          |
| 40              | 543.1177106      | 68              | 7.987           | 544          |
| 50              | 678.8971383      | 85              | 7.987           | 680          |
| 60              | 814.676566       | 102             | 7.987           | 816          |

The thirty second detention time is optimal since a moderate detention time would allow for a less aggressive mixing over shorter periods of time. The moderate mixing allows for similar outcomes at a lower cost and less wear and tear on the mechanical equipment.

The power required is given by the following equation

$$G = 900 \text{ s}^{-1}$$

$$P = G^2 \times V \times \mu$$

Where,

P = Power

G = Velocity Gradient =  $900 \text{ s}^{-1}$

$\mu$  = Dynamic Viscosity

$$P = (900 \text{ s}^{-1})^2 \times 408 \text{ m}^3 \times (1.002 \times 10^{-3}) = 331,140.96 \frac{\text{N} \cdot \text{m}}{\text{s}} = 331.1 \text{ kW}$$

The average Texas commercial electricity rate is 7.98 ¢/kWh (31% lower than the national average).<sup>[7]</sup> Therefore, the Average Cost per kW hour is given by

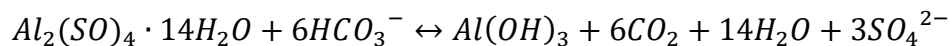
$$331.1 \text{ kW} \times \frac{\$ 0.0798}{\text{kWhr}} \times \frac{24 \text{ hr}}{1 \text{ d}} \times \frac{30 \text{ d}}{1 \text{ month}} = \frac{\$ 19,023.68}{\text{Month}}$$

### 3.6 COAGULATION

The Coagulation is a process used for both water and wastewater treatment methods.

Coagulation is an essential chemical-driven process in water and wastewater treatment. The use of chemical reagents to destabilize and increase the size of the particles; mixing; increasing of floc size, a physical separation of the solids from the liquid phase. This separation is usually achieved by sedimentation (decantation), flotation or filtration.

Coagulation and flocculation are often the first steps in water treatment. Chemicals with a positive charge are added to the water. The positive charge of these chemicals neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals and form larger particles, called floc. Many types of particles may settle out of water on their own over a sufficient period of time; however, this may take days or months depending on the particle size (from molecules to bacteria) and their relative colloidal stability. The destabilization of a colloidal system with an appropriate coagulant-flocculants enables formation of a floc network that facilitates solids removal by physical methods. The induction of Alum, a known coagulant, allows the neutralization of the negatively charged suspended soils and is represented by,



Where,

$$Alum = Al_2(SO)_4 \cdot 14H_2O = 594 \text{ g}$$

$$Alkalinity = 6HCO_3^- = 366 \text{ g}$$

$$Floc = Al(OH)_3 = 156 \text{ g}$$

Each mole of alum uses 6 moles of alkalinity and produces 2 moles of aluminum hydroxide (solid) and 6 moles of CO<sub>2</sub> which decreases the pH, however in the presence of alkalinity pH won't lower drastically.

| Constituent                              | Concentration (mg/L) |
|------------------------------------------|----------------------|
| Total Alkalinity (as CaCO <sub>3</sub> ) | 169                  |

alkalinity does not decide alum dose only jar test will let us know. you chekc and see if there is enough alkalinity so there wont be ph change

$$\frac{\text{Alum Dose}}{\text{Alum MW}} = \frac{\text{Alkalinity}}{\text{Alkalinity MW}} \rightarrow$$

$$\text{Max Alum Dose} = \frac{\text{Alkalinity} \times \text{Alum MW}}{\text{Alkalinity MW}} = \frac{169 \frac{\text{mg}}{\text{l}} \times 594 \text{ g}}{366 \text{ g}} = 274.3 \frac{\text{mg}}{\text{l}}$$

this totally wrong

The maximum dose is the amount necessary to neutralize the entire alkalinity in the water.

However, adjustments must be made to maintain the alkalinity at twenty-five percent of alum dose to keep the alkalinity stable.

$$274.3 \frac{\text{mg}}{\text{l}} \times (1 - 0.25) = 205.73 \frac{\text{mg}}{\text{l}}$$

$$169 \frac{\text{mg}}{\text{l}} - \left( \frac{205.73 \frac{\text{mg}}{\text{l}} \times 366 \text{ g}}{594 \text{ g}} \right) = 42.2 \frac{\text{mg}}{\text{l}}$$

$$\text{Remaining Alkalinity} = 42.2 \frac{\text{mg}}{\text{l}}$$

Alum is measure to determine the maximum amount required for the water while monitoring the alkalinity levels in the water to ensure a safe balance.

$$205.73 \frac{\text{mg}}{\text{l}} \times 309.9 \times 10^6 \frac{\text{gal}}{\text{day}} \times \frac{3.785 \text{ L}}{1 \text{ gal}} \times \frac{30 \text{ days}}{1 \text{ month}} \times \frac{1 \text{ kg}}{10^6 \text{ mg}} = 1,045,117.61 \frac{\text{kg}}{\text{month}}$$

Therefore, we conclude that the resulting Alum per month is

$$\text{Alum per month} = 1,045,118 \frac{\text{kg}}{\text{month}}$$

The pricing for alum is  $0.20 \frac{\$}{\text{kg}}$  to  $0.40 \frac{\$}{\text{kg}}$ .<sup>[9]</sup>

$$1,045,117.61 \frac{\text{kg}}{\text{month}} \times \frac{\$0.40}{\text{month}} = \$418,047$$

Therefore, it is concluded that

$$\text{Alum cost per month} = \$418,047$$

### 3.7 FLOC PRODUCTION

The precipitates formed must be brought into contact with one another and colloids so that they can agglomerate and form larger particles called flocs. The production of floc can be determined from the alum reaction in the above reaction. The flocculation production is determined by the given relationship:

$$\frac{\text{Alum Dose}}{\text{Alum MW}} = \frac{\text{Floc}}{\text{Floc MW}} \rightarrow$$

$$\text{Floc Produced} = \frac{\text{Alum Dose} \times \text{Floc MW}}{\text{Alum MW}} = \frac{205.73 \frac{\text{mg}}{\text{l}} \times 156 \text{ g}}{594 \text{ g}} = 54.03 \frac{\text{mg}}{\text{l}}$$

$$54.03 \frac{\text{mg}}{\text{l}} \times 309.9 \times 10^6 \frac{\text{gal}}{\text{day}} \times \frac{3.785 \text{ L}}{1 \text{ gal}} \times \frac{30 \text{ days}}{1 \text{ month}} \times \frac{1 \text{ kg}}{10^6 \text{ mg}} = 1,901,273.1 \frac{\text{kg}}{\text{month}}$$

$$\text{Floc produced per month} = 1,901,274 \frac{\text{kg}}{\text{month}}$$

### 3.7.1 FLOCCULATION TANK

The flocculation chamber is the next phase that helps reduce the turbulence flow into sedimentation tank. The flocculation tank consist of three chambers designed to reduce the turbulence. For design purposes the flocculation tank depth will be the same as the settling tank depth. And the max flocculation tank width will be the same as the settling tank width.

Pursuant to Texas Commission on Environmental Quality (Revised Dec. 2019) of §290.42(d)(9)(B)(i) Flocculation facilities for straight-flow and up-flow sedimentation basins shall provide a minimum theoretical detention time of at least 20 minutes when operated at their design capacity. Flocculation facilities constructed prior to October 1, 2000, are exempt from this requirement if the settled water turbidity of each sedimentation basin remains below 10.0 nephelometric turbidity units and the treatment plant meets with turbidity requirements of §290.111 of this title. However, according to the Ten State Standard The detention time for floc formation should be at least 30 minutes with consideration to using tapered (i.e., diminishing velocity gradient) flocculation. The water depth in basin is in the range of 3-5m as a rule of thumb. The TAC RULE §290.42 for Water Treatment requires a water depth of at least 12 ft. For design purposes, the below precedents are selected,

$$Q_{Total} = 309,942,504 \frac{gal}{day} = 309.9 MGD$$

$$G_1 = 80 s^{-1}, G_2 = 40 s^{-1}, G_3 = 20 s^{-1}$$

$$\theta = Detention Time = 30 min$$

$$L = D; D = 4.5 m$$

The total volume of all three sections of flocculation basin is given by

$$V = \theta \times Q$$

$$V_{Total} = 309.9 \times 10^6 \frac{gal}{day} \times 30 \min \times \frac{3.785 L}{1 gal} \times \frac{1 m^3}{1,000 L} \times \frac{1 hr}{60 \min} \times \frac{1 day}{24 hr} = 6,456.25 m^3$$

$$\cong 7,000 m^3$$

you will match flocc basins to sed tanks

The number of flocculation tanks is equal to that of rapid mixing tanks. The total volume for the flocculation tanks is determined by the flow rate with product of detention time. The number of flocculation tanks to ensure a proportionate amount of coagulant is used to treat the water.

$$V_{Tank} = \frac{V_{Total}}{\# Tank} = \frac{7,000 m^3}{51} = 137.25 m^3$$

The volume per tank is then partitioned into three sections to reduce the turbulence of water flow which helps in keeping the floc suspended until settlement occurs in the sedimentation basin.

$$V_{per Tank Section} = \frac{V_{Total}}{3} = \frac{137.25 m^3}{3} = 45.75 m^3$$

$$V_{per Tank Section} = L \times W \times D = W \times D^2 \rightarrow W = \sqrt{\frac{V_{Tank Section}}{D^2}}$$

$$W = \sqrt{\frac{137.25 m^3}{(4.5 m)^2}} = 6.78 m$$

The tank dimension for each section will be as follows.

$$L = 4.5 m; W = 6.78 m; D = 4.5 m$$

However, the three section partition must be taken into account. Therefore, the length is factored by three.

$$L = 13.5 m; W = 6.78 m; D = 4.5 m$$

Each section of the flocculation will require different mixing gradients. The Power for each section is given by

$$P = G^2 \times V \times \mu$$

Section 1:

$$P = (80 \text{ s}^{-1})^2 \times 137.25 \text{ m}^3 \times (1.002 \times 10^{-3} \frac{\text{N} \cdot \text{s}}{\text{m}^2}) = 38,957.76 \frac{\text{N} \cdot \text{m}}{\text{s}} \times \frac{1 \text{ kW}}{1000 \frac{\text{N} \cdot \text{m}}{\text{s}}} \\ = 0.880 \text{ kW}$$

Section 2:

$$P = (40 \text{ s}^{-1})^2 \times 137.25 \text{ m}^3 \times (1.002 \times 10^{-3} \frac{\text{N} \cdot \text{s}}{\text{m}^2}) = 38,957.76 \frac{\text{N} \cdot \text{m}}{\text{s}} \times \frac{1 \text{ kW}}{\frac{\text{N} \cdot \text{m}}{\text{s}}} \\ = 0.220 \text{ kW}$$

Section 3:

$$P = (20 \text{ s}^{-1})^2 \times 137.25 \text{ m}^3 \times (1.002 \times 10^{-3} \frac{\text{N} \cdot \text{s}}{\text{m}^2}) = 38,957.76 \frac{\text{N} \cdot \text{m}}{\text{s}} \times \frac{1 \text{ kW}}{\frac{\text{N} \cdot \text{m}}{\text{s}}} \\ = 0.055 \text{ kW}$$

The Total Power per Tank = 1.16 kW

The Total Power over all tanks = Total power per tank  $\times$  51 Tanks = 58.91 kW

$$\text{Cost} = 58.91 \text{ kW} \times \frac{\$0.12}{\text{kW} \cdot \text{hr}} \times \frac{24 \text{ hrs}}{1 \text{ day}} = \frac{\$169.65}{\text{day}}$$

$$\text{Cost per Month} = \$5,089.5$$

### 3.8 SEDIMENTATION TANK

The sedimentation process is used to reduce particle concentration in the water. The advantage of sedimentation is that it minimizes the need for coagulation and flocculation. Typically, chemicals are needed for coagulation and flocculation, but improved sedimentation controls the need for additional chemicals. Sedimentation is a physical process used to eliminate Turbidity and suspended matter, organic matter, color, and suspended solids which serves as a contaminant for water treatment. The water enters the sedimentation at the inlet zone and directs to the settling zone where the suspended solids settle. The water flows to the outlet zone as the

formed floc settles in the sludge zone. For design purposes and pursuant to Texas Commission on Environmental Quality (Revised Dec. 2019) of §290.42(d)(10)(C)(i) When operated at their design capacity, basins for straight-flow or up-flow sedimentation of coagulated waters shall provide either a theoretical detention time of at least six hours in the flocculation and sedimentation chambers or a maximum surface overflow rate of 0.6 gpm/sq ft of surface area in the sedimentation chamber. For the purpose of being conservative seven hour detention time will be used. Therefore, the design parameters are given by,

$$Q = 309.9 \text{ MGD}$$

$$\theta = \text{Detention Time} = 7 \text{ hours} \text{ a little high but k}$$

$$OFR = \frac{40 \text{ m}^3}{d \cdot \text{m}^2} \text{ where did you get this from?}$$

$$A = \frac{Q}{OFR}$$

$$\text{Total Area} = \frac{309.9 \times 10^6 \frac{\text{gal}}{\text{day}} \times \frac{3.785 \text{ L}}{1 \text{ gal}} \times \frac{1 \text{ m}^3}{1,000 \text{ L}}}{\frac{40 \text{ m}^3}{d \cdot \text{m}^2}} = 29,324.29 \text{ m}^2$$

The design criteria for each tank will be given by 51 tanks is not acceptable

$$\text{Total Area} = \frac{29,324.29 \text{ m}^2}{51} = 575 \text{ m}^2$$

$$\text{Area per Tank} = \frac{\pi}{4} \times D^2 \rightarrow D = \sqrt{\frac{(\text{Area per Tank}) \times 4}{\pi}} = \sqrt{\frac{(575 \text{ m}^2) \times 4}{\pi}} = 27.06 \text{ m}$$

$$V = Q \times \theta$$

$$V_{\text{Total}} = 309.9 \times 10^6 \frac{\text{gal}}{\text{day}} \times \frac{3.785 \text{ L}}{1 \text{ gal}} \times \frac{1 \text{ m}^3}{1,000 \text{ L}} \times 7 \text{ hrs} \times \frac{1 \text{ day}}{24 \text{ hr}} = 342,116.69 \text{ m}^3$$

$$\text{Depth} = \frac{V_{\text{Total}}}{\text{Total Area}} = \frac{342,116.69 \text{ m}^3}{29,324.29 \text{ m}^2} = 11.7 \text{ m}$$

Therefore the sedimentation dimensions will be 27.06 *m* in diameter and 11.7 *m* in depth. The volume of each tank is given by;

$$V_{per\ Tank} = 6,728.70\ m^3$$

### 3.5 FILTRATION

Water flows through a filter designed to remove particles from within it. The filters are made of layers of sand and gravel, and in some cases, crushed anthracite. Filtration collects the suspended impurities in water, enhancing the effectiveness of disinfection. These filters are routinely cleaned by backwashing. Filtration is a physical process used to eliminate suspended solids, Turbidity, organic matter, color, and suspended matter which serves as a contaminant for water and wastewater treatment. Filtration happens when the water then passes through different types of filters (sand, gravel, and charcoal) with different pore sizes to remove any dissolved particles. Once the floc has settled to the bottom of the water supply, the clear water on top will pass through filters of varying compositions (sand, gravel, and charcoal) and pore sizes, in order to remove dissolved particles, such as dust, parasites, bacteria, viruses, and chemicals. The Rapid sand filters are used for optimum filtration due to sand and tight pores. The number of filters are given by

$$N = 0.0195 \times (Q)^{0.5}$$

Such that

$$N = 0.0195 \times \left( 309.9 \times 10^6 \frac{gal}{day} \times \frac{3.785\ L}{1\ gal} \times \frac{1\ m^3}{1,000\ L} \right)^{0.5} = 21.12 \cong 22\ filters$$

$$A_{Total\ filters} = \frac{Q}{OFR}$$

Pursuant to the TAC RULE §290.42 (11)(B)(i) The design capacity of gravity rapid sand filters shall not exceed a maximum filtration rate of 2.0 gpm/sq ft. At the beginning of filter runs for declining rate filters, a maximum filtration rate of 3.0 gpm/sq ft is allowed.

$$\frac{309.9 \times 10^6 \frac{\text{gal}}{\text{day}}}{2 \frac{\text{gal}}{\text{min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{24 \text{ hr}}{1 \text{ day}} \times \frac{1 \text{ m}^2}{10.76 \text{ ft}^2}} = 10,000.38 \text{ m}^2$$

$$A_{\text{per filter}} = \frac{A_{\text{Total; filters}}}{\# \text{ Filters}}$$

$$A_{\text{per filter}} = \frac{10,000.38 \text{ m}^2}{21} = 476.21 \text{ m}^2$$

$$\frac{L}{W} = 1.3 \rightarrow A = L \times 1.3 \times W \rightarrow A = W^2 \times 1.3$$

$$W = \sqrt{\frac{\text{Area}}{1.3}}$$

$$W = \sqrt{\frac{476.21 \text{ m}^2}{1.3}} = 19.14 \text{ m}_{\text{ok}}$$

$$W = 19.14 \text{ m}; L = 24.9$$

Next, the rapid sand filters are cleaned by backwash such that the volume of backwash water (BWV) required per filter unit is given by

$$BWV = \text{time of wash} \times \text{filter area} \times \text{rise of backwash water}$$

$$= 10 \text{ min} \times 107,643.194 \text{ ft}^2 \times 24 \frac{\text{in}}{\text{min}} \times \frac{1 \text{ ft}}{12 \text{ in}}$$

$$= 2,152,863.88 \text{ ft}^3 \times 7.48 \frac{\text{gal}}{\text{ft}^3} = 16,103,421.82 \text{ gallons}$$

The percent of backwash water volume as a percent of total water treated is given by

$$\% = \frac{16,103,421.82 \text{ gallons}}{309,942,504 \text{ gallons}} \times 100 = 5.196 \%$$

### 3.6 DISINFECTION

The disinfection basin is sized to provide a specified hydraulic residence time at peak flow conditions. Ten states standard (1978) recommends a design value of 15 minute residence time. The values are given as follows;

$$Q = 309.9 \times 10^6 \frac{\text{gal}}{\text{day}}$$

$$\theta = \text{Detention Time} = 15 \text{ minutes}$$

$$\frac{L}{W} = 40$$

$$D = 4 \text{ m}$$

$$V_{Total} = 309.9 \times 10^6 \frac{\text{gal}}{\text{day}} \times 15 \text{ min} \times \frac{3.785 \text{ L}}{1 \text{ gal}} \times \frac{1 \text{ m}^3}{1,000 \text{ L}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ day}}{24 \text{ hr}} = 12,218.45 \text{ m}^3$$

$$V_{Tank} = \frac{V_{Total}}{\# \text{ Tank}} = \frac{12,218.45 \text{ m}^3}{50} = 244.37 \text{ m}^3 \cong 245 \text{ m}^3$$

$$V = L \times W \times D \rightarrow W = \sqrt{\frac{V_{Tank \text{ Section}}}{D^2}}$$

$$W = \sqrt{\frac{245 \text{ m}^3}{40 \times 4}} = 1.24 \text{ m} \rightarrow L = 49.5 \text{ m}$$

The Filter dimension will be as follows,

$$L = 49.5 \text{ m}; W = 1.24 \text{ m}$$

Chlorination is a method used to inactivate pathogens by damaging its cell membrane. Once the cell membrane is weakened, the chlorine can enter the cell and disrupt cell respiration and DNA activity. Chlorine is added to raw water material to eliminate algae and other aquatic life to avoid problems in the later stages of water treatment. Pre-chlorination in the flash mixer is found to remove tastes and odors, and control biological growth throughout the water treatment system, thus preventing growth in the sedimentation tanks. The addition of chlorine will also oxidize any iron, manganese and/or hydrogen sulphide that are present, so that they too can be removed in the sedimentation and filtration steps. Chlorination is a chemical process used to eliminate pathogenic organisms which serves as a contaminant and for biodegradable organisms. The benefits of chlorine is that Reduces many disagreeable tastes and odors; Eliminates slime bacteria, molds and algae that commonly grow in water supply reservoirs, on the walls of water mains and in storage tanks; and Helps remove iron and manganese from raw water. The effects of chlorination in wastewater is that it reduces the population of organisms in the wastewater to levels low enough to ensure that pathogenic organisms will not be present in sufficient quantities to cause disease when the wastewater is discharged. Chlorinating filtered water is more cost effective because a lower combination of concentration by contact time is required. By the time water reaches sedimentation and filtration a lot of unwanted organisms are eliminated in the process of chlorine interaction. The drawback of chlorine is that it lingers in the environment and is accumulated with time.

### **3.7 STORAGE**

Water will be stored and transferred securely. Stabilization helps protect water lines from corrosion. Polyphosphate is a chemical added to the water as a corrosive prevention measure. Corrosive waters can lead to a public health hazard including lead poison. The water then flows to fluoridation which is safe and economical. The fluoride dose is precisely distributed. A strong bleach is added to the water (ie. sodium hypochlorite) and is done to keep chlorine in the water until it reaches the communities faucet. Lastly, pumping systems are used to ensure constant water flow regardless of power outages or natural disasters. Thus, electric powered or diesel powered pumps are the common options.

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