MIDDLE EAST TECHNICAL UNIVERSITY

DEPARTMENT OF CIVIL ENGINEERING

CE 410 - CIVIL ENGINEERING DESIGN

TAŞUCU TOWN WASTE WATER COLLECTION PROJECT

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Group Members :

CONTENT

1. WASTEWATER / STORMWATER COLLECTİON SYSTEMS

We will design wastewater collection system in this course for Taşucu town, Silifke in Mersin. We determined place of wastewater treatment plant and pumping stations; line of sewers and force mains according to our several calculations and investigations which will be mentioned in detail below.

Wastewater collection systems are used to collect and transmit liquid wastes to a central treatment plant.Wastewater from individual homes, businesses and industries enters the collection system through a service line.

The ancient Romans were one of the first civilizations to employ wastewater collection through clay pipes and covered cannel sewers.Modern wastewater collection systems are a combination of components that include; sewers, force mains, manholes, and pump stations.

Sewer: Component of system which conveys the sewage.

Figure 1

Force mains: is a pressurized **main** pipe that can carry water, sewage, and other materials.

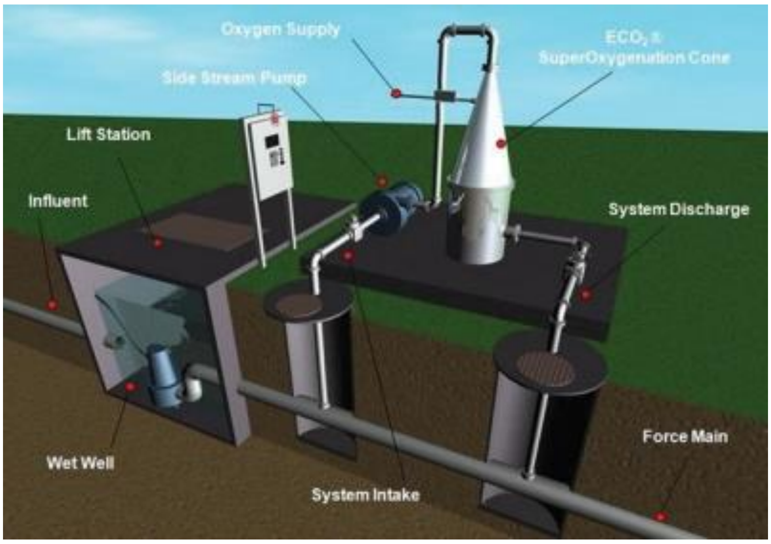


Figure 2

Manhole: is the top opening to an underground utility vault used to house an access point for making connections, inspection, valve adjustments or performing maintenance on underground and buried public utility and sewers.

Figure 3

Pump stations: are facilities including pumps and equipment for pumping fluids from one place to another.

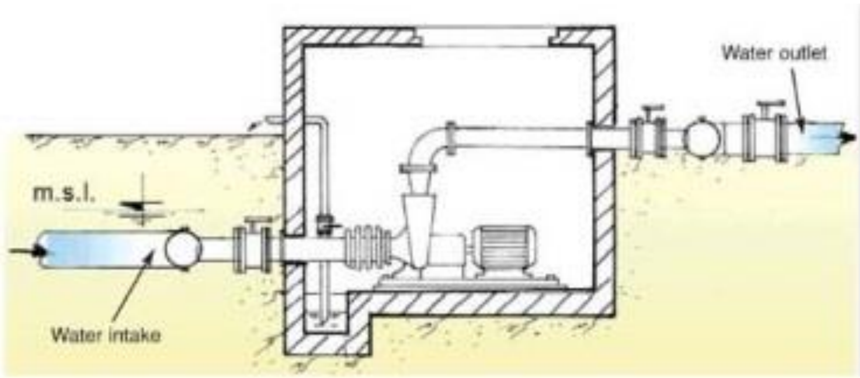


Figure 4

INTRODUCTION OF TAŞUCU

Taşucu is a town of Silifke, Mersin. Taşucu has a coast on Mediterranean, and is surrounded with Akdere town in west, center of SilifkeCounty in northeast and Göksu delta. There is forest area in north of town.

Taşucu takes 10,533 hectare space. Taşucu which located in Mediterranean region has typical meditrraean climate. Therefore, summer is hot and dry; winter is soft and rainy there. The average temperature of this town is 19.5 Celsius degree. Due to this good weather condition, Taşucu is the important touristic place of Turkey, so economy of town depends on tourism. In addition to tourism, commerce, fishing and agriculture are means of existence in this town.

Town is on a rolling terrain, between 0.0 elevation in coast and 100.0 elevation in north. Since, most part of living site is on bottom land, slope of site is almost 5%.

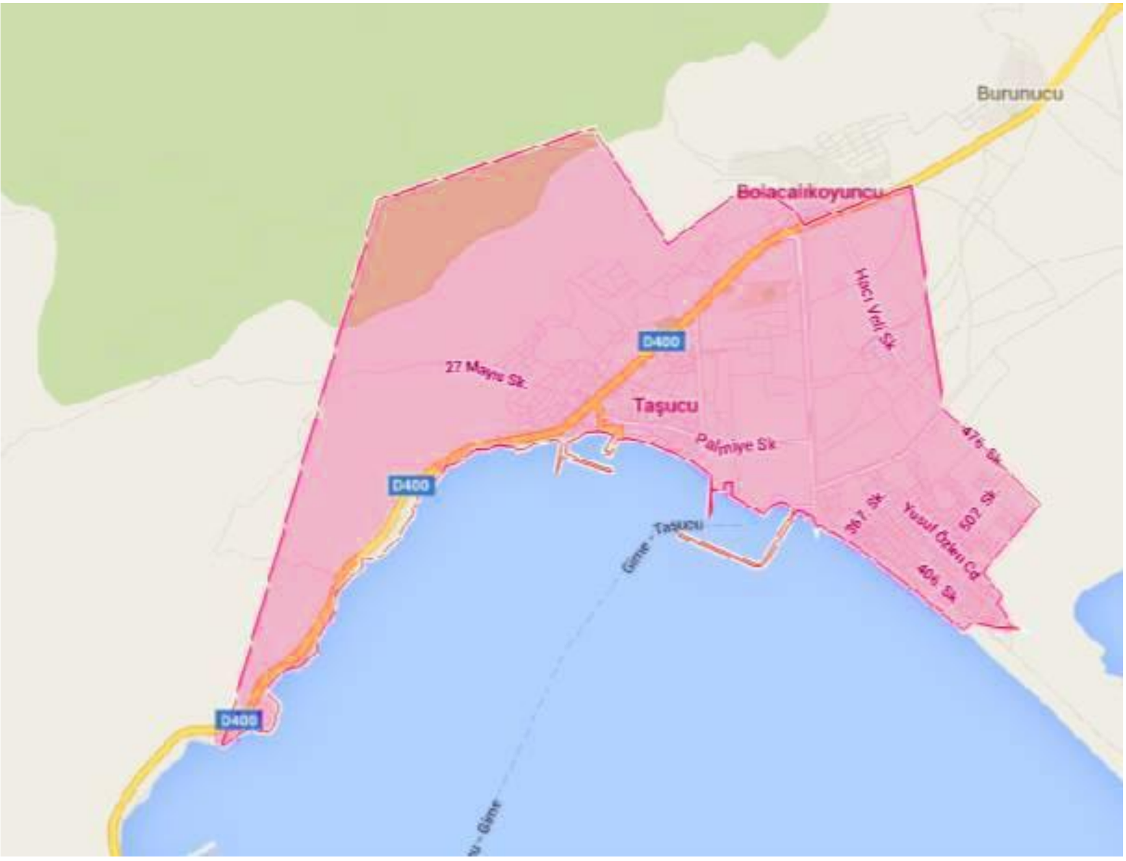


Figure 5

2. POPULATION PLANNING

2.1. Introduction:

Population project is the helpful or useful tool to reflect and to digitize a region in terms of social and economical point of view. The population project is defined as making the estimation of changing of the population in the future based on assumptions of future trend for birth, deaths and migration acts. The population project can be done with different scale for different purposes such as the settlements or administrative agency having different population greatness or administrative agency besides the whole around the country, region and province.

The population projection is being done in order to prepare development plan scene since the beginning of the planning and design process. It aims to submit for one's review to present applications of scientific and demographic models, which are essential parts of preparing development plan, as much as possible in population planning; including the more common and simple methods for planning studies as well. Although the prediction methods which will be elaborated in this report are guide for users, users should take into account that the methods should be updated or new methods should be developed in case the condition have changed and the accuracy of population prediction could be high by unique approaching of themselves.

In the first step of this study, the estimation of population methods will be covered. In the second step, the different methods will be compared and the best method will be selected and the result will be used for waste water project. In the third step, a short summary will be done and the comment for the project will be shared.

2.2. Location:

The place which the project will be done is Taşucu Neighborhood, Mersin. The view of Google Map can be seen in the 'Figure 6' .

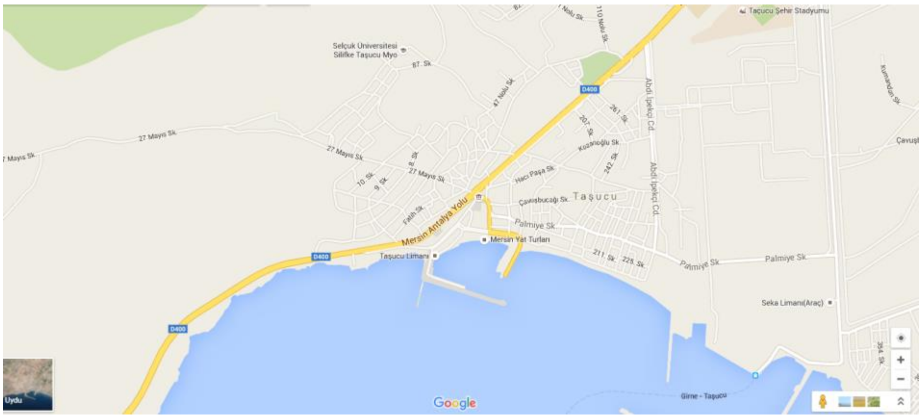


Figure 6: The Google Map View of Taşucu Region

2.3. Scope and Goal:

The scope of population planning is only Taşucu in Mersin. To estimate the population of Mersin, the recent data of population census which belongs to Taşucu, Mersin was used.

The main goal to find population of Taşucu is making the project properly. Because the finding population is very important issue. The average life of a project is generally 50 years. Therefore, any project should be designed and done by considering future. If the capacity of the project does not supply the demand of the region, that would be a dead invest and would be money waste. For this reason, the population of Taşucu region should be found out correctly.

Therefore, the main purpose in this report is finding Taşucu population in the year of 2050.

2.4. Population Estimation:

The population increases by births, decreases by deaths. The migrations affect the population with either increasing or decreasing. These components are under the impression of social and economical factors. The shape of changing the population in years is 'S' most of all. (Figure ...) The initial speed of increasing population is low and this level increases in time and reach its maximum point.

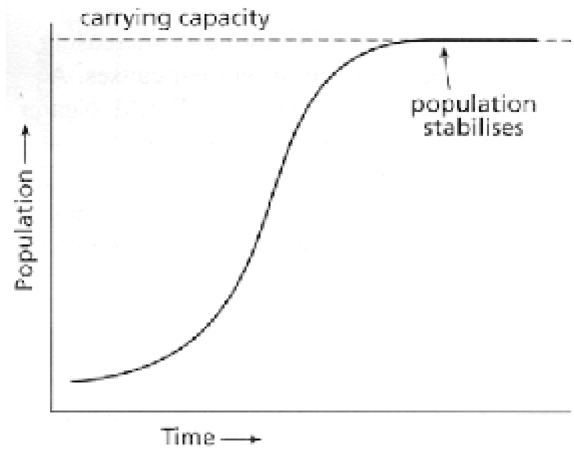


Figure 7: The shape of population growth

2.4.1 The Population Estimation Methods:

The population estimation methods to find a region basically are listed below.

- Graphical Method
- Arithmetic Increasing Method
- Geometric Increasing Method
- Bank of Provinces Method

2.4.1.1. Graphical Method:

In this method, the population versus time graph should be plotted. The axis of graph should be time and the ordinate of the graph should be population. The graphs whose ordinate population help designers to see trend of the population in the future. Then, the population trend of a region can be drawn simply. The equation of a trend line can be observed easily and the future estimation can be made.

The available data of Taşucu population is listed in the 'Figure 8' .

Time	Population
1965	2257
1970	2132
1975	2983
1980	4535
1985	4385
1990	6743
1995	8401
2000	10466
2007	7820
2010	8392
2012	8847

Figure 8: The available data of Taşucu Region

The time versus population graph and the trend line of the population can be seen below.

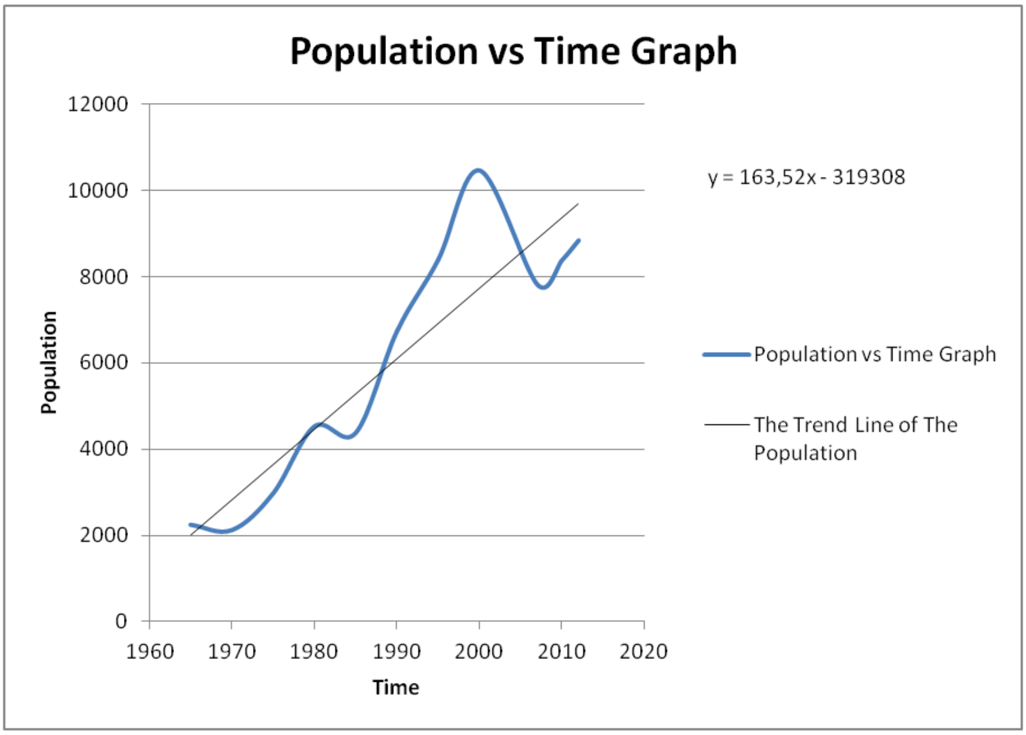


Figure 9: The population graph and trend line

The equation of trend line is:

$$ThePopulation = 163{,}52 * Time - 319308$$

Then, in 2050 ;

y = 163,52 * 2050 - 319308 = 16000 person (Approximately)

2.4.1.2. Arithmetic Increasing Method:

This method is a mathematical method that both two axis of a graph points in a graphical paper having arithmetic scale as if previous population values became a straight line situation. In this situation, the increasing rate of population is constant, in other words, the tangent of the curve is also constant.

There are equations for calculation.

k_a= The arithmetic increasing speed constant ($d_y/d_t = k_a$)

$$\int_{y_1}^{y_2} y = k_a \int_{t_1}^{t_2} t$$

$$y_s - y_i = k_a (t_s - t_i)$$

$$k_a = (y_s - y_i)/(t_s - t_i)$$

y_s= Last Population
y_i= Initial Population
t_s= Last time
t_i= Initial time

The population versus time graph for 1965 and 2012 years and the equation of trend line based on 1965 and 2012 years can be seen in the 'Figure 10 '.

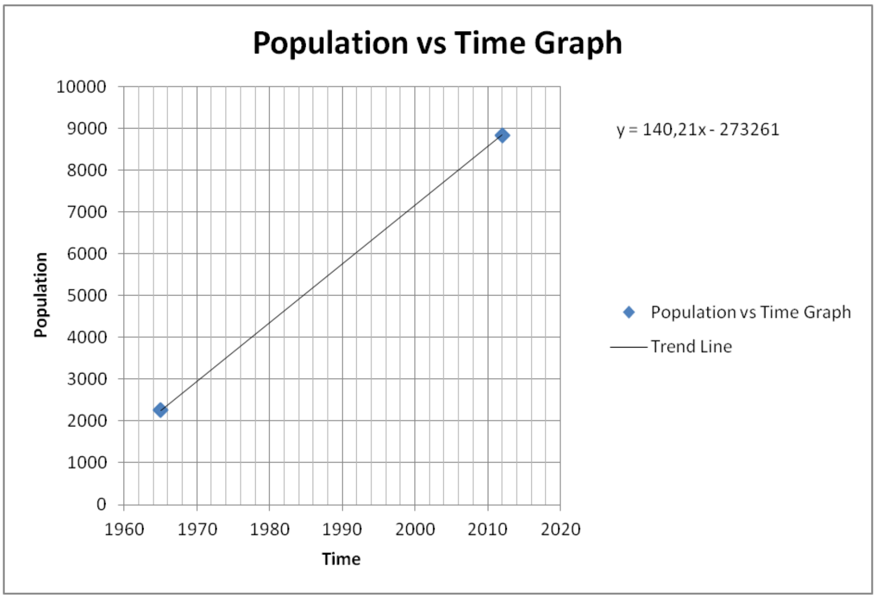


Figure 10: Population versus Time Graph for arithmetic method

$$ThePopulation = 140{,}21 * Time - 273261$$

Then, in 2050;

The Population= 140,21*2050- 273261 = 14200 people (Approximately)

2.4.1.3. Geometric Increasing Method:

In this method, the increasing rate of the population per unit time is accepted as related with the present population. According to this, the population change rate can be written as dy/dt=kg .k_g represents geometric increase rate constant.

The useful equations can be seen below.

$$\int_{y_i}^{y_s} \frac{dy}{y} = k_g \int_{t_i}^{t_s} t$$

$$\ln \frac{y_s}{y_i} = k_g (t_s - t_i)$$

Then Equation Becomes

$$k_g = (\ln y_s - \ln y_i)/(t_2 - t_1)$$

kg = (In(Ny)-In(Ne))/(ty-te) = (In(8847)-In(2257))/(2012-1965) = 0.0291

Population Projection :

In (Ng) = In (Ny) + kg * (tg - ty) = In (8847) + 0.0291 * (2050-2012)

Ng = 34000 person (Approximately)

2.4.1.4. Bank of Provinces Method:

According to drink water ordinance of directorate general of bank of provinces, it is forecasted as below expressions for drink water and canalization projects preparation which is sustained by bank of provinces method.

$$y_g = y_s * \left(1 + \frac{Ç}{100}\right)^{30+5+g}$$

y_g= Future Population Ç= reproduction coefficient

y_s = Present Population g = The time from last population counting to planning

30= Project Service Time (year)   5: The time for planning, design, bidding, construction

$$Ç = \left(\sqrt[a]{\frac{y_y}{y_e}} - 1 \right) * 100$$

y_e = First population data   a= the time difference y_y and y_e

Also, there are limitations for Ç values

If

- Ç<1   ; Ç= 1
- Ç>3   ; Ç=3
- 1<Ç<3   ; Ç= Calculated Value

y_y = 8847   ; y_e = 2257   ;   a= 2012-1965 = 47 years

Then;

$Ç = 100 * ((\frac{8847}{2257})^{1/(2012-1965)} - 1) = 2.949$

Then, the first equation can be applied as below.

$$y_g = y_s * \left(1 + \frac{Ç}{100} \right)^{30+5+g}$$

$y_{2050} = y_{2012} * (1 + \frac{2.949}{100})^{(35+2050-2012)}$; $y_{2012} = 8847$

y_{2050} = 27000 person (approximately)

2.4.2. Comparison of Methods:

The comparison result can be seen in 'Table 1'

Table 1: The Comparison of all methods

Time	Population	Graphical Method	Artihmatic Method	Geometric Method	Bank of Provinces Method
1965	2257	2009	2252	-	-
1970	2132	2826	2953	-	-
1975	2983	3644	3654	2389	3174
1980	4535	4462	4355	4117	9102
1985	4385	5279	5056	6950	14793
1990	6743	6097	5757	6273	14304
1995	8401	6914	6458	10280	21996
2000	10466	7732	7159	12874	27404
2007	7820	8877	8140	17631	36220
2010	8392	9367	8561	10472	24045
2012	8847	9694	8842	10911	24706
2050	No information	15908	14170	33561	73833

The comparison graphs can be seen in 'Figure 11'

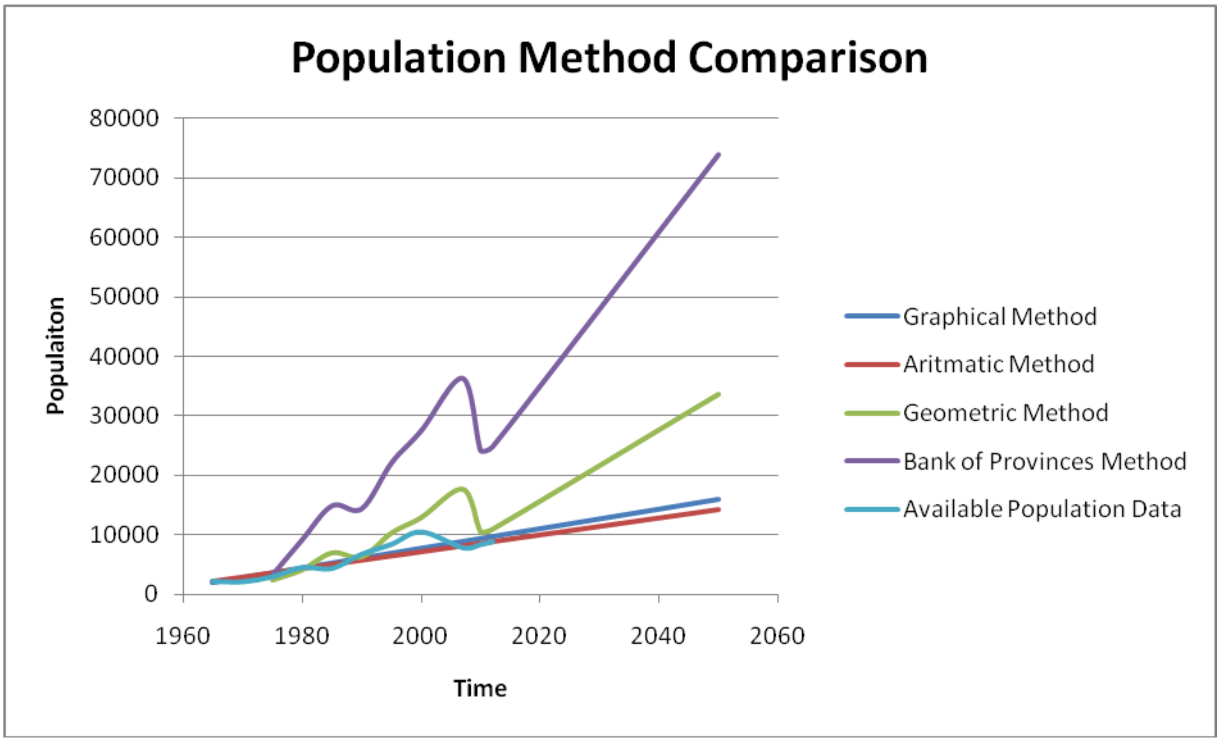


Figure 11: All graphs in together for estimation of population methods

2.4.3. Summary, Conclusion and Comments:

The results for Graphical, Arithmetic, Geometric and Bank of Provinces Methods are approximately 16000,14200,34000 and 74000 respectively.

The population of waste water project was selected as 60000 people. There were two considerations. The first one is whether the project would supply the demand of people in the region or not. Therefore, the methods which give around 16000, 15000 and 34000 was not selected. The more population was selected, as a result of this the capacity of pipe line would be enough for Taşucu. The second consideration is that the population should not be exaggerated.

Also, according to ministry of environment and urbanization data, the estimated population of Taşucu in 2025 is 50000 people.

In the light of all numerical population data and design concerns, the population was selected as **60000** people instead of 74000 people in bank of provinces method. The main reason is reducing the cost of the project. If population of 74000 was selected, the cost of the project of Taşucu waste water would be extremely high, therefore the population of 60000 was considered as future of Taşucu in 2015, the population estimation is also a reasonable estimation for ministry of environment and urbanization data.

3. **WASTE WATER CALCULATION AND DIAMETER SELECTION**

In the design of sewage water amount, potable water is taken as reference point.

Table 2: Potable water demand according to population (illerbankası)

population	Potable water demand(l/p/d)
3000	60
3000-5000	60-80
5000-10000	70-80
10000-30000	80-100
30000-50000	100-120
50000-100000	120-170

Table 3 : Total water demand

Type of consumption	Consumption per person daily (l/p/d)	Project year consumption per person* (l/p/d)	Project target year consumption per person** (l/p/d)
Household (q_{home})	80-140	76	97
Commerce, construction, service, industry (%5-10*q_{net})	(q_{net})*0.05-0.10	0.10*89 = 9	0.10*108 = 11
Net Consumption (q_{net})	(q_{home})/0.90-0.95	80 / 0.90 = 89	97 / 0.90=108
Losses (q_{loss}) (%10-20*q_{gross})***	(q_{gross})*0.10-0.20	0.10*99 = 10	0.10*120 = 12
Total (q_{gross})	**(q_{net}) + (q_{loss})**	**89/0.90=99**	**108/0.90 =120**

Table 4: Water demand for Kum neighborhood

facility	water demand(l)	present unit	predicted unit	unit per facility	water
pension(per person)	190	1	7	50	66500
hotel(per bed)	300	4	15	100	450000
swimming pool	500l/m^2	3	10	-	500000*

***the area of the pool is assumed to be 100 m^2

total demand	3032500
demand per person(l/p/d)	180,5

Table 5: Total sewage values obtained from the parts of the map

parts of the map	sewage(l/s/p)	areas(ha)	p/ha	total sewage(l/s)
1	120	340	50	23,61
2	120	430	60	35,83
3	180	210	80	35

Kutter's equation

$$V = \frac{100\sqrt{R}}{b + \sqrt{(J * R)}} \sqrt{(J * R)}$$

Q=V*F

F : Area of the pipe while the pipe is full (m^2)

R : F/r: hydraulic diameter

J : mean velocity of the sewage (m/s)

Q : discharge of the sewage (m^3/s)

b : coefficient of roughness

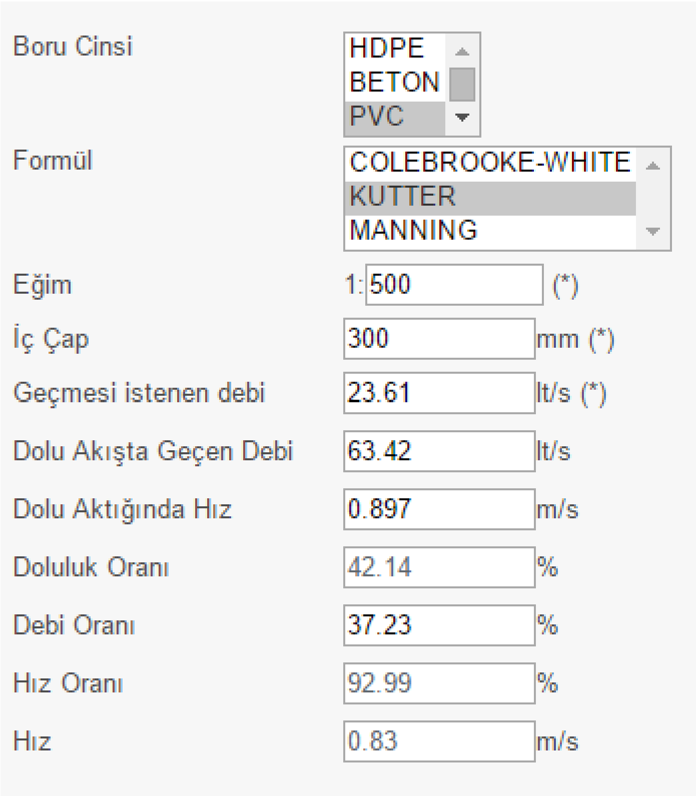
r : wetted perimeter

Table 6: Minimum and Maximum Velocities in Sewer Pipes

Pipe Description	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Design Velocity (m/s)
Gravity pipe	0.5	2.5	0.75
Pressure pipe	0.6 to 1.0	2.5	1.5

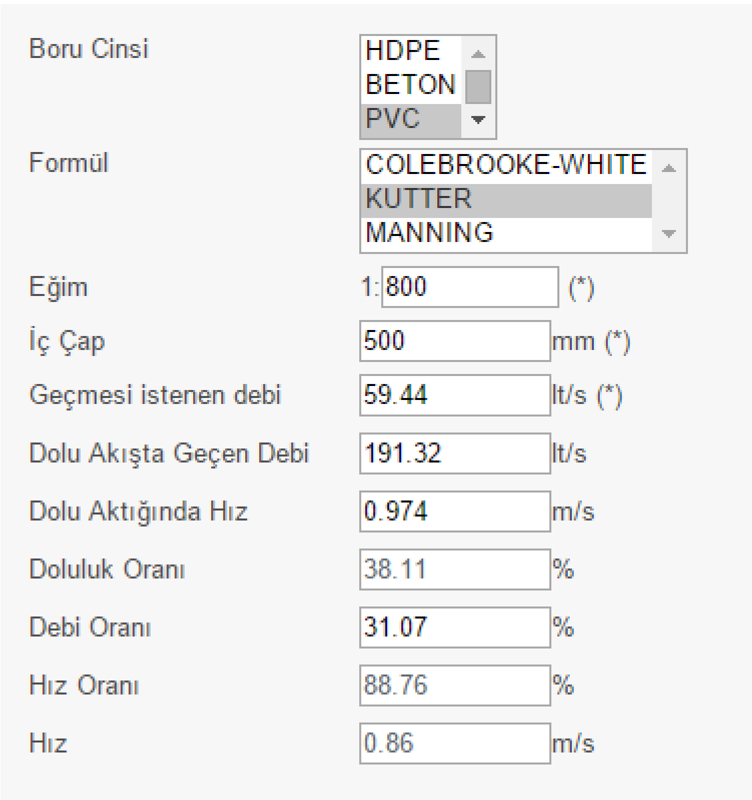
Table 7: Grade standards for sewage works

diameter(mm)	minimum grade	maximum grade	fullness ratio	manhole distance(m)
φ200	300	7	40	50
φ300	500	7	50	60
φ400	600	25	60	70
φ500	800	25	60	70
φ600	1000	25	60	70
φ800	1200	50	60	80
φ1000	2000	75	70	100
φ1200	2050	75	70	125
φ1400	2100	75	80	150
φ1600	2150	75	80	150
φ2000	2250	75	80	150
φ3000	2500	75	80	150



Boru Cinsi	HDPE BETON PVC	
Formül	COLEBROOKE-WHITE KUTTER MANNING	
Eğim	1: 500	(*)
İç Çap	300	mm (*)
Geçmesi istenen debi	23.61	lt/s (*)
Dolu Akışta Geçen Debi	63.42	lt/s
Dolu Aktığında Hız	0.897	m/s
Doluluk Oranı	42.14	%
Debi Oranı	37.23	%
Hız Oranı	92.99	%
Hız	0.83	m/s

Figure 12: Diameter selection and the calculation of the pipe fullness for part 1(Dizayn group)



Boru Cinsi	HDPE BETON PVC	
Formül	COLEBROOKE-WHITE KUTTER MANNING	
Eğim	1: 800	(*)
İç Çap	500	mm (*)
Geçmesi istenen debi	59.44	lt/s (*)
Dolu Akışta Geçen Debi	191.32	lt/s
Dolu Aktığında Hız	0.974	m/s
Doluluk Oranı	38.11	%
Debi Oranı	31.07	%
Hız Oranı	88.76	%
Hız	0.86	m/s

Figure 13: Diameter selection and the calculation of the pipe fullness for part 2 (Dizayn group)

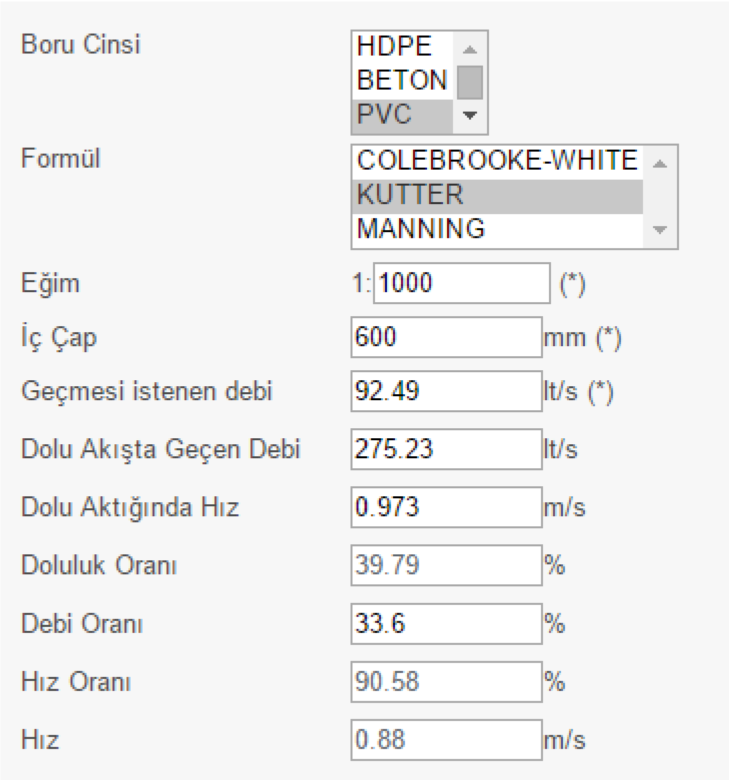


Figure 14: Diameter selection and the calculation of the pipe fullness for part 3 (Dizayn group)

4. DİSCHARGES & PUMP SELECTİON :

<u>For 35 years :</u>

Q12 = $\frac{210*80*170}{12*3600}$ = 66 lt/s   Q18 = $\frac{210*80*170}{18*3600}$ = 44 lt/s   Q37 = $\frac{210*80*170}{37*3600}$ = 21 lt/s

	Q37 (lt/s)	Q18 (lt/s)	Q12 (lt/s)
25 YEARS	18.00	37.00	55.00
35 YEARS	21.00	44.00	66.00

	Q (lt/s)	PUMP TYPE
25 YEARS	3*33	PLUNGER TYPE
35 YEARS	3*33	PLUNGER TYPE

Differences of water consumption at certain times in a day are important for the hydraulic calculations. Change in water consumption create different discharges for hourly, daily and even weekly. To make the calculations in the safe side, discharge for 12 hours in a day is used in the calculations.

3 pumps are used in the pumping station since discharges show differences according to the seasons. Since Taşucu is tourism province, the population has been increasing sharply in the summer. The differences discharges in the summer and winter have been increasing. To provide energy effienciency, the pumps which can work for different discharges properly are used.

Plunger pumps are used as a pump type. They are feasible for small discharges (less than 100 - 150 lt/s). The important advantage of plunger pumps is low cost maintenance and no need extra place to install pumps therefore it makes plunger pumps cheaper compared to other type of pumps. Another advantage is that plunger pumps do not cause vibrations and noise since they run in the fluid.

Circular caisons are used since Kum Neighborhood has weak soil. Also, installation of the caissons is easy. Diameter of the caissons should not exceed 7 meters.

As a material type of the pipeline, polyethylene(HDPE) pipes are chosen. Because, it has high flexibility which allows the pipe not to break and being uneffected from underground movements. Also, it has high impact strength and high resistance to crack.

4.1.Motor Power Calculation :

Calculations of motor power are done according to the pump discharges for 25 years since economic life of pumps and air chambers is 25 years.

H_g = final elevation of pump line - pump axis elevation

$H_g = (2.50) - (-9.10) = 11.60$ m

$Q_p = 55$ lt/s

$J = f_s * \frac{v^2}{D*2g}$

Boru Malzemelerine Göre f_s değerleri:

AÇB	CTP	ÇELİK	POLİETİLEN	BETON
0,013-0,016	0,01-0,012	0,020-0,024	0,011-0,013	0,011-0,015

For polyethylene, f = 0.012

Q = v * A

$55*10^{-3} = v * (\pi * (0.15)^2)$ where D = 300 mm $\rightarrow$ v = 0.78 m/s

$J = 0.012 * \frac{(0.78)^2}{0.3*2*9.81} \rightarrow J = 0.00123$ m/m

L = 712 m → JL = 0.00123*712 = 0.88 m

$H_m = H_g + JL$ + minor losses = 11.60 + 0.88 + 2.00 → $H_m = 14.5$ m

$N_e = \frac{Q*H_m}{102*\mu} = \frac{55*14.5}{102*0.5} \rightarrow N_e = 15.6$ kW

$N_e = 15.6$ kW → E.K. = 1.25

$N_m = N_e$ * E.K. = 15.6*1.25 → $N_m = 19.5$ kW

$N_m = 19.5$ kW → n=8

Ne	E.K.
0 < Ne < 7,5KW	1,5
7,5 ≤ Ne < 22KW	1,25
22 ≤ Ne < 55KW	1,15
55 ≤ Nc	1,1

Motor Gücü(N)	Şalt Sayısı(n)
0<N<7,5KW	10
7,5≤N<30KW	8
30≤N<110KW	6
110≤N	4

Calculation of the Volume of Collecting Chamber :

$T_{min} = \frac{3600}{n}$ For n=8, $T_{min} = 450$ s

$V_1 = \frac{T_{min}*Q_p}{4} = \frac{450*66}{4} \rightarrow V_1 = 7425$ lt

$V_2 = 0.392 * V_1 = 0.392*7425 \rightarrow V_2 = 2911$ lt

$V_3 = 0.264 * V_1 = 0.264*7425 \rightarrow V_3 = 1960$ lt

$V_R = 1704$ lt is taken.

$V_T = V_1 + V_2 + V_3 + V_R = 7425 + 2911 + 1960 + 1704 \rightarrow V_T = 14000$ lt = 14 m^3

Base Area of Collecting Chamber :

$F = \pi * r^2 = 3.14 * (2.50)^2 \rightarrow F = 19.63\ m^2$ where diameter of caisson is taken as 5.00 m.

When concrete of bottom slope is considered, $F_{net} = A = 15\ m^2$

$h_1 = \frac{V_1}{A} = \frac{7.425}{15} \rightarrow h_1 = 0.50$ m

$h_2 = \frac{V_2}{A} = \frac{2.911}{15} \rightarrow h_1 = 0.19$ m

$h_3 = \frac{V_3}{A} = \frac{1.960}{15} \rightarrow h_1 = 0.13$ m

$h_R = \frac{V_R}{A} = \frac{1.704}{15} \rightarrow h_1 = 0.11$ m

$h_ö$ is taken as 0.80 m.

$H_T = h_1 + h_2 + h_3 + h_R + h_ö \rightarrow H_T = 1.73$ m

4.2.Pump Station

4.2.1.Valve House

When pump station is shut down, valve house is used for making sewage stop to flow. Valve house will build just before the grille and will include butterfly valve which will be according to DIN 3216.

4.2.2.Grille

It will need to separate bulk meterials from row sewage. It will be appropriate for Iller Bankasi standarts.

4.2.3. Pipe Station Dimensions

Valve house enter pipe base elevation : -7.57 m

Basket grille enter pipe base elevation :-7.58 m

Basket grille exit pipe base elevation : -8.09 m

Pipe station enter pipe base elevation : -8.1 m

Pump station base elevation :0,5 m

Pump axis elevation: -9.1 m

Pump room base elevation : -8.3 m

Final elevation of pipeline :2.5 m

Pressure pipeline : Φ 300mm L = 712 m

4.3. Storm Water Calculatıons

Storm Water Discharges :

In the calculations, rational method is used. Rational method is the method that gives the best result. It is assumed that the rain falls the whole area uniformly.

Q = C * I * A

where ;

Q = storm water discharge (lt/s)

C = runoff coefficient depending on drainage area and type of rainfall

I = Rainfall intensity (lt/s/ha)

A = Area (ha)

Collecting time, $T = T_g + T_a$(minutes)

T_g = Entrance time ; It is the time that raindrops that drop the remotest point of the water collecting area come to the beginning of the canal.

Slope	Entrance Time (min.)
J > 1/20	5
1/20 > J > 1/50	10
1/50 > J	15

T_a = Runoff time ; It is the elapsed time between two points in the section where storm water passes.

$T_a = \frac{L}{V*60}$ (min)   V = conduit runoff velocity (m/s)

Average runoff coefficients are shown below considering reconstruction densities.

TYPE OF DRAINAGE AREAS	RUNOFF COEFFICIENTS (C)
COMMERCIAL ZONES	
Central Zones	0.70 - 0.95
Outskirt	0.50 - 0.70
REZIDENTIAL ZONES	
Isolated houses with garden	0.30 - 0.50

Multi-storey isolated blocks	0.40 - 0.60
Multi-storey adjacent blocks	0.60 - 0.75
Residential Areas	0.25 - 0.40
INDUSTRIAL ZONES	
Light Industrial Zones	0.50 - 0.80
Heavy Industrial Zones	0.60 - 0.90
ROADS	
Asphalt Pavement	0.70 - 0.95
Concrete Pavement	0.80 - 0.95
Durax-cube Pavement	0.70 - 0.85
Green Areas, Parks & Graveyards	0.10 - 0.25
Sports Arena	0.20 - 0.35

General Criteria :

In the storm water conduits, concrete pipes whose section is circular or B.A. pipes and reinforced concrete pipes whose section is rectangular are usually used.Selection of conduits whose section is rectangular is more appropriate where the slope is very few. When concrete pipe is used, minimum diameter of conduit will be Φ300 mm. Kutter Equation is used in the concrete pipes as the sewerage conduits and Manning Equation is used in the conduits whose section is rectangular.

Manning Equation :

$Q = V * A$

$V = \frac{1}{n} * R^{2/3} * S^{1/2}$

Q = discharge that can pass through the selected section (m^3/s)

V = velocity (m/s)

n = Manning roughness coefficient (0.015)

R = Hydraulic Radius (m)

S = Slope

Wastewater treatment plants which are available and will be installed and intersections will be controlled, necessary distances between conduits will be provided.

Storm water grille places will be shown on the project. Absolute grille installation will be specified with control organization in the stage of practice according to the last situation of pavements and roads.

When rectangular sections are planned, canals have freeboard to flow the water regularly. Since duration of storm water runoff is less than the duration of waste water runoff, maximum velociy can be taken as 5 m/s and Manning equation is used to specify the section discharge.

Inlets are used to take the storm water to the conduits.

When the storm water drainage system is planned, discharging of the storm water to the nearest places is taken into account.

Minimum diameter of conduits that has circular section will be Φ300 mm and it allows the conduits to flow 100 % fully and Kutter equation is used to specify the conduit section discharge.

In places where totally 80-100 lt/s storm water discharge is formed in 2 borders, conduit planning will be done.

In circular section conduits, minimum ground cover will be h = 1.20 m.

In rectangular section conduits, minimum ground cover will be taken as h = 1.20 m but it decreases to 0.20 m in unavoidable situations.

Manholes will be installed as in the sewerage system and water that is collected in inlets will be connected with Φ300 mm concrete pipe to the main conduit. To connect the inlets to the manholes is more appropriate in terms of maintenance and management.

In inlet grilles, grilles whose dimensions are 60-40 cm will be used and placed parallel to the road to increase the capacity.