The Optimum Location of Diwaniyah Sewage Treatment Plants

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Abstract

The purpose of this research is to decide the optimum location of a wastewater treatment plant in terms of people health and environmental aspects of AL-Diwaniyah city. However, the waste water only from the districts was disposed to treatment plants so as to recycle them and then into river water which it is represented by AL-Diwaniyah river along the Shatt AL-Hillah that divides the city into two parts.

The aim of this research is to find the least path of conveyance of the wastewater treatment plant and to achieve the least cost of treatment.

This research based on twenty eight districts in Diwaniyah city are selected districts to be studied and grouped into three parts to be investigated in terms of sea level. The direction of the winds was also considered as an important factor to evaluate the suitability of the proposed positions. In addition, the district No. 1 is already serviced by the No. 1 treatment plant. Google Earth was used to determine most of the investigated parameters. Linear programming by (Win QSB) Program technique was also adopted to optimize the selected positions of treatment plants.

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الخلاصة

الغرض من هذا البحث هو تحقيق الوصول الى الموقع الامثل لوحدة المعالجة الخاصة بالصرف الصحي كونها تؤثر على صحة الإنسان والبيئة في مدينة الديوانيه.على أية حال، أن المناطق المشمولة بالصرف الصحي تؤخذ مياه مجاريها الى وحدات المعالجه لمعالجتها ومن ثم الى النهر الذي هو يمثل شط الديوانيه(أمتداد شط الحله) الذي يقسم المدينة إلى جزأين.

أهداف هذا البحث هو وصول مياه المجاري من المناطق المدروسة إلى وحدات المعالجه الخاصة بها بأقصر طريق ووقت ممكن ، الحصول على موازنة بين القدرة التصميميه لوحدات المعالجةَ وكمية مياه مجاري الواصله من تلك المناطق، وأخيراً، تحقيق أقل كلفة في عملية التخلص من مياه الصرف الصحي .

لإنْجاز هذه الأهداف، تم تسمية ثمان وعشرون منطقة رئيسيه في مدينة الديوانيه مختارة من مجموعة البيانات الاحصائيه لمناطق الديوانيه التي تم الحصول عليها بالتعاون مع المجلس المحلي في المدينه، بحيث قُسمتْ المدينه إلى ثلاثة أقسامِ تَضمن كُلّ قسم وحدة معالجه واحدة بالإعتماد على مستوى المناطق الخاصة بها عن سطح البحر. مع الجدير بالذكر انه تم تحديد مناطق وحدات المعالجه والمناطق البديله لها من الناحيه البيئيه (اتجاه الرياح في كل منطقه) واستملاكات الاراضي المحيطه بها من قبل الدوائر المعنيه في المدينه، بالإضافة الى أن المنطقةَ الاولى(القسم الاول) مخدوم اصلا من قبل وحدة المعالجة رقم واحد بحيث تم حساب الإرتفاعات للمناطق من خلال مساعدة برنامج (Google Earth) كون أن مياه المجاري تنصرف من الحد الاعلى الى الحد الادنى ومن ثم إلى وحدات المعالجةَ الخاصة بكل قسم وبعدها إلى النهر. كذلك تم التعامل مع طرق متطورة من عمليات البحوث الهندسيه لتحقيق الوصول الى الموقع الأمثل والمعروفه (برمجة الاهداف) وهي طريقة خاصة من البرمجة الخطية من قبل برنامج (Win QSB) الذي تم استخدامه للوصول الى الاهداف المذكور اعلاه.

1. Introduction

In many densely populated areas, the increasing in consuming water was caused by the different industrial and housing activities. The item of "sewage" is used to describe the wastewater that can be disposed by pipes to the treatment plants from the city to be recycled.

Of course, the treatment plants are not something novel at present, but it became very essential matter since a long time ago during 19th century. The public health got worse and disease spread everywhere because of poisonous sewage flow thrown into the rivers, marshes and then to lands. As a result of this problem, sewage treatment plants become necessary; therefore, some laws had been enacted to protect the public health. The environment analysis was taken into consideration the social and physical phenomena to locate the treatment plant. Also, the relationship between the humans where they live and the environmental impact of the treatment plant location in addition to its side effects like rancid, noise, architectural design and other environmental factors should be considered in the engineering design(Fair and Geyer, 1971) .

In general, the domestic sewage contains about (99%) water while the remaining part (1%) is polluted material which is called "waste material". In order to execute any sewage project, the average daily sewage flow can be obtained by multiplying the number of people living in the area by the daily water consumption per capita (Fair and Geyer, 1971).

2. Study Objectives

According to the engineering requirements, and to get the benefit from the program of optimum solution to locate sewage treatment plants, the statistical and engineering analysis of the results were provided on two basis considerations:

1. To choose the suitable location for sewage treatment plant.
2. To achieve an economical solution among the possible solutions.
3. To get a balance between the design capacity of the sewage treatment plant and the amount of sewage areas of the population.

3. Data Collection Method

This research is focused on sewage disposal from populated area to the treatment plants and then to the river. Figure (1) illustrates the method of the city classification into three sections depending on its level from the sea surface by using Google Earth and the section No. 1 for the neighborhoods serviced by the No. 1 treatment plant. Thus through this section has been two sections No.2 and No.3.

To locate the treatment plant, the sewage was streamed from the higher level to the lower level of those districts by pipelines with (1200 mm) diameter. The cost of one meter of pipeline was (175$) according to the prices of the local market. The average daily of water consumption per capita has been estimated to be (0.25 m^3). while the design capacity of the treatment plant is (22500 m^3/day) (Diwaniyah Council Office, 2007, 2008; Specifications of the Standard Sewage Service, 1988) .

The number of population had been depended on the taken information from Diwaniyah Census Office(2007, 2008). The treatment plants (1, 2, and 3) were located at the district which had the minimum elevation in the city section as shown in Figure (1).

Table (1) states the names of districts in Diwaniyah city, according to its level form the sea surface, and length of the trunk lines. Table (2) shows the number of population in each district in addition to average daily of water consumption.

4. The Formulating of The General Template

The (Win QSB) Program solves linear goal programming (GP) and integer linear goal programming (IGP). A GP and IGP problems involve one or more linear goals (objective function) and limited number of linear constrains. Decision variables may be bounded with limited values. All decision variables are considered continuous in nature; that is, any real value within the bounds. The general form of linear goal programming problem in (GP-IGP) has the following format(Lee, 1972; Nesa and Richard, 1980; Safa, 2006):

$$Minimize\ Z = \sum_{i=1}^{n} P_i (n_i + p_i)$$

Subject to

$$Minimize\ Z = (\sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} X_j + ... + C_{nm} X_m) + n_i - p_i = b_i \qquad \text{(Goal level } i\text{)}$$

Where

Z: objective function

P_i : Goal priority

X_j: decision variable

C_{ij} : coefficient of decision variable

b_i: absolute value in constriction

n_i: the degree of the minimum achievement of goal

p_i: the degree of the maximum achievement of goal

Strictly, since (p_i, n_i) could not be added together, so one of them or both must be zero. Hence:

$$p_i \, . \, n_i = 0$$

To solve this problem, the researcher were assumed the variable (X_{ijk}) to represent the quantity of disposed sewage from the district *i* to treatment plant *j* in the city section *k*.

The template can be formulated depending on the goals preparing by Al-Qadissiya Sewage Office by using the collected data shown in Tables (1) and (2) of supposed plants in Figure (1).

The collected data were input into program to proceed the goals as shown below:

4.1. The First goal: includes 28 constrains. Each one of them might be represented the quantity of sewage (m^3/day) for each district that disposed to the treatment plant as follows:

$x_{111} + n_1 - p_1 = 5062.5$

$x_{211} + n_2 - p_2 = 5656$

$x_{311} + n_3 - p_3 = 9187.5$

$x_{411} + n_4 - p_4 = 875$

$x_{511} + n_5 - p_5 = 2438.5$

$x_{611} + n_6 - p_6 = 2835.7$

$x_{711} + n_7 - p_7 = 1196.7$

$x_{811} + n_8 - p_8 = 2875$

$x_{911} + n_9 - p_9 = 3000$

$x_{(10)11} + n_{10} - p_{10} = 3375$

$x_{(11)11} + n_{11} - p_{11} = 7295$

$x_{(12)11} + n_{12} - p_{12} = 5375$

$x_{122} + n_{13} - p_{13} = 4375$

$x_{222} + n_{14} - p_{14} = 19312.5$

$x_{322} + n_{15} - p_{15} = 2892.5$

$x_{422} + n_{16} - p_{16} = 1125$

$x_{522} + n_{17} - p_{17} = 2738.5$

$x_{622} + n_{18} - p_{18} = 2063.5$

$x_{722} + n_{19} - p_{19} = 1875$

$x_{133} + n_{20} - p_{20} = 125$

$x_{233} + n_{21} – p_{21} = 6972$
$x_{333} + n_{22} – p_{22} = 635.7$
$x_{433} + n_{23} – p_{23}= 2403.7$
$x_{533} + n_{24} – p_{24} = 1900$
$x_{633} + n_{25} – p_{25} = 1925$
$x_{733} + n_{26} – p_{26} = 387.5$
$x_{833} + n_{27} – p_{27} = 1950$
$x_{933} + n_{28} – p_{28} = 1552.5$

4.2. The Second Goal: includes 3 constrains for the supposed plants to get the balance for the design capacity of the plant and disposed sewage from the district to the plant of the sewage:

$x_{111}+ x_{211} + x_{311} + x_{411} + x_{511}+ x_{611}+ x_{711} + x_{811} + x_{911}+ x_{(10)11}+ x_{(11)11}+ x_{(12)11}+ n_{29} – p_{29} = 22500$
$x_{122} + x_{222} + x_{322} + x_{422} + x_{522} + x_{622} + x_{722} + n_{30} – p_{30} = 22500$
$x_{133} + x_{233} + x_{333} + x_{433} + x_{533} + x_{633} + x_{733} + x_{833} + x_{933} + n_{31} – p_{31} = 22500$

4.3. The Third Goal: includes 3 constrains representing the sewage disposal in a short way from the districts to the plants:

$3000x_{111} +800 x_{211} +1500 x_{311} +1460x_{411} +575 x_{511} + 850 x_{611} +1700x_{711} +1736 x_{811} +750 x_{911}$
$+ 1430x_{(10)11} +1623 x_{(11)11} +2625 x_{(12)11} + n_{32} – p_{32} =0$
$1400 x_{122} +2900 x_{222} +2450 x_{322} + 1035 x_{422} +1385 x_{522} +1762 x_{622} +813 x_{722} + n_{33} – p_{33} = 0$
$760 x_{133} +1500 x_{233} +2000 x_{333} +1300 x_{433} + 2350 x_{533} + 2900 x_{633} +3500 x_{733} +4000 x_{833} +$
$1462 x_{933} + n_{34} – p_{34} = 0$

4.4. The Fourth Goal: includes one constrain representing the cost of sewage disposal from the districts to the plants:

$525000 x_{111} +140000 x_{211} + 262500 x_{311} + 255500 x_{411} + 100625x_{511} + 148750 x_{611} +$
$297500x_{711} + 303800 x_{811} + 131250 x_{911} + 250250 x_{(10)11} + 284025 x_{(11)11} + 459375 x_{(12)11} +$
$245000 x_{122} + 507500 x_{222} + 428750 x_{322} + 181125 x_{422} +242375 x_{522} + 308350 x_{622} + 142275$
$x_{722} + 133000 x_{133} + 262500 x_{233} +350000 x_{333} + 227500x_{433} + 411250 x_{533} + 507500x_{633} +$
$612500 x_{733} + 700000x_{833} + 255850 x_{933} + n_{35} – p_{35} = 0$

5. The Solutions and Discussion:

For the purpose of the study and application the statistical and engineering analysis of the results to get the benefit from the program of optimum solution to locate sewage treatment plants nearby populated area required more than one solution to change the positions of these plants(Omega, 2007). It needs determining the optimum solution according to the results that output from the program. Brief descriptions of these solutions are as follows:

5.1. The First Solution

In order to achieved the goals that mentioned before, the input data of supposed plants (1,2,3), as shown in Figure (1), were considered. The program should be run to get the results as shown in the Table (4) and as follows:

5.1.1. The First Goal: the given value was zero. This represents the total quantities of sewage taken form districts and disposed to treatment plants of the city sections but there is a surplus in the second district through table (4).

$p_{19} = 7478,0$

5.1.2. The Second Goal: It had not processed yet, so after run the program, the given value was (Q_P=27821m^3/day). In fact, it was obtained in the operation of the program and it was related to the items of this goal as shown below:

$p_{29} + p_{31} = 311,5 + 27509,5 = 27821,0$

According to engineering analysis, this means that those three treatment plants can possibly have a design capacity more later. So the number of (27821 m^3/day) was represented the additional quantity of sewage flow that could possibly included to the design capacity of the treatment plants in the future.

5.1.3. The Third Goal: It had not proceeded yet, its value was (194,128,172 m.m^3/day). It was obtained in the operation of the program and it was related to the items of this goal as shown below:

$p_{32} + p_{33} + p_{34} = 69،446,320 + 88,260,448 + 36,421,404 = 194,128,172$

According to engineering analysis, the number of (194,128,172) was represented the multiplying of the total length of pipeline by the quantity of sewage flow which is about (27821 m^3/day) in the future. Therefore, the length of the pipelines that used to dispose the sewage could be obtained by dividing the mentioned value above on the quantity of sewage flow. The result was (6,978 m) which is represented the possible length of pipelines that including the design capacity of the three treatment plants in the future.

5.1.4. The Fourth Goal: It has not been processed yet, its value was (*33,970,810,880* \$.m^3/day).

It was obtained in the operation of the program and it was related to the items of this goal as shown below: $p_{35} = 33,970,810,880$

According to engineering analysis, the number of (*33,970,810,880*) was represented the cost of sewage disposal which is about (27821 m^3/day) in the future. Therefore, the cost that used to dispose the sewage could be obtained by dividing the mentioned value above on the quantity of sewage flow. The result was (1221 \$) that including the designed capacity of those three treatment plants and sewage network in the future.

5.2. The Second Solution:

In this solution, the input data of supposed plants (1, 2*, 3) were considered. The treatment plant (2) was moved away to (2*) while other plants (1, 3) were fixed as shown in Figure (2). Subsequently, the cost and lengths of the pipelines connected to those plants were varied. In similar way the new statements have been input as items and re-operated the program to have obvious results in the Table (5) as follows:

5.2.1. The First Goal: the given value was zero. This represents the total quantities of sewage taken form districts and disposed to treatment plants of the city sections but there is a surplus in the second district through table (5).

$p_{16} = 7478,0$

5.2.2. The Second Goal: It had not processed yet, so after run the program, the given value was (7,478m^3/day). It was related to the items of this goal as shown below:

$p_{29} + p_{31} = 311,5 + 27509,5 = 27821,0$

According to engineering analysis, this means that those three treatment plants can possibly have a design capacity more later. So the number of (27821 m^3/day) was represented the additional quantity of sewage flow that could possibly included to the design capacity of the treatment plants in the future.

5.2.3. The Third Goal: It had not proceeded yet, its value was (*182,766,244*m.m^3/day). It was obtained in the operation of the program as shown below:

$p_{32} + p_{33} + p_{34} = 69،446,320 + 76,898,520 + 36,421,404 = 182,766,244$

According to engineering analysis, the number of (*182,766,244*) was represented the multiplying of the total length of pipeline by the quantity of sewage flow which is about (27821 m^3/day) in the future. Therefore, the length of the pipelines that used to dispose the sewage could be obtained by dividing the mentioned value above on the quantity of sewage flow. The result was (6,569 m) which is represented the possible length of pipelines that including the design capacity of the three treatment plants in the future.

5.2.4. The Fourth Goal: It has not been processed yet, its value was (*31,982,473,216* \$.m^3/day).It was obtained in the operation of the program and it was related to the items of this goal as shown below:

$p_{35} = 31,982,473,216$

According to engineering analysis, the number of (*31,982,473,216*) was represented the cost of sewage disposal which is about (27821 m^3/day) in the future. Therefore, the cost that used to dispose the sewage could be obtained by dividing the mentioned value above on the quantity of sewage flow. The result was (1149,6 \$) that including the designed capacity of those three treatment plants and sewage network in the future.

5.3. The Third Solution:

In this solution, the input data of supposed plants (1,2,3*) were considered. The treatment plant (3) was moved away to (3*) while other plants (1,2) were fixed as shown in Figure (3). Subsequently, the cost and lengths of the pipelines connected to those plants were varied. In similar way the new statements have been input as items and re-operated the program to have obvious results in the Table (6) as follows:

5.3.1. The First Goal: the given value was zero. This represents the total quantities of sewage taken form districts and disposed to treatment plants of the city sections but there is a surplus in the second district through table (6).

$p_{19} = 7478,0$

5.3.2. The Second Goal: It had not processed yet, so after run the program, the given value was (7,478m^3/day). It was related to the items of this goal as shown below:

$p_{29} + p_{31} = 311,5 + 27509,5 = 27821,0$

5.3.3. **The Third Goal**: It had not proceeded yet, its value was (*187,014,192* m.m^3/day). It was obtained in the operation of the program as shown below:

$p_{32} + p_{33} + p_{34} = 69,446,320 + 88,260,448 + 29,307,424 = 187,014,192$

According to engineering analysis, the number of (*187,014,192*) was represented the multiplying of the total length of pipeline by the quantity of sewage flow which is about (27821 m^3/day) in the future. Therefore, the length of the pipelines that used to dispose the sewage could be obtained by dividing the mentioned value above on the quantity of sewage flow. The result was (6.722 m) which is represented the possible length of pipelines that including the design capacity of the three treatment plants in the future.

5.3.4. The Fourth Goal: It has not been processed yet, its value was (*32،302,030,848* \$.m^3/day). It was obtained in the operation of the program and it was related to the items of this goal as shown below:

$p_{35} = 32,302,030,848$

According to engineering analysis, the number of (*32,302,030,848*) was represented the cost of sewage disposal which is about (27821 m^3/day) in the future. Therefore, the cost that used to dispose the sewage could be obtained by dividing the mentioned value above on the quantity of sewage flow. The result was (1161,10 \$) that including the designed capacity of those three treatment plants and sewage network in the future.

5.4. The Fourth Solution:

In this solution, the input data of supposed plants (1,2*,3*) were considered. The treatment plants (2,3) were moved away to (2*,3*) while plant (1) was fixed as shown in Figure (4). Subsequently, the cost and lengths of the pipelines connected to that plants were varied. In similar way the new statements have been input as items and re-operated the program to have obvious results in the Table (7) as follows:

5.4.1. The First Goal: the given value was zero. This represents the total quantities of sewage taken form districts and disposed to treatment plants of the city sections but there is a surplus in the second district through table (7).

$p_{16} = 7478,0$

5.4.2. The Second Goal: It had not processed yet, so after run the program, the given value was (7478 m^3/day). It was related to the items of this goal as shown below:

$p_{29} + p_{31} = 311,5 + 27509,5 = 27821,0$

***5.4.3.* The Third Goal**: It had not proceeded yet, its value was (*175,652,264* m.m^3/day). It was obtained in the operation of the program as shown below:

$p_{32} + p_{33} + p_{34} = 69,446,320 + 76,898,520 + 29,307,424 = 175,652,264$

According to engineering analysis, the number of (*175,652,264*) was represented the multiplying of the total length of pipeline by the quantity of sewage flow which is about (27821 m^3/day) in the future. Therefore, the length of the pipelines that used to dispose the sewage could be obtained by dividing the mentioned value above on the quantity of sewage flow. The result was (6,314 m) which is represented the possible length of pipelines that including the design capacity of the three treatment plants in the future.

5.4.4. The Fourth Goal: It has not been processed yet, its value was (*30,737,235,968* \$.m^3/day). It was obtained in the operation of the program and it was related to the items of this goal as shown below:

$p_{35} = 30,737,235,968$

According to engineering analysis, the number of (*30,737,235,968*) was represented the cost of sewage disposal which is about (27821 m^3/day) in the future. Therefore, the cost that used to dispose the sewage could be obtained by dividing the mentioned value above on the quantity of sewage flow. The result was (1104,82 \$) that including the designed capacity of those three treatment plants and sewage network in the future.

6. The Conclusions And Recommendations:

According to the obtained results from the (Win QSB) Program, the optimum solution that can be the best to locate the treatment plants was the first solution. This solution indicates that the sewage tratment plants could be occupies more pipeline lengths, about

(6,978 m) almost (7 m), with adequate cost (1221$) inorder to enlarge the seweage network of city planning in the future as shown in the table (1) below.

Table (1) Final results

Value	First Solution	Second Solution	Third Solution	Fourth Solution
First goal	0	0	0	0
Second goal(m^3/day)	27,821	27,821	27,821	27,821
Third goal($m.m^3$/day)	194,128,172	182,766,244	187,014,192	175,652,264
Fourth goal($\$.m^3$/day)	33,970,810,880	31,982,473,216	32,302,030,848	30,737,235,968
Total length(m)	6,978	6,569	6,722	6,314
Cost($)	1221	1149,6	1161,10	1104,82

However the sewage projects in general and the treatment plants in particular were designed with higher costs, but they had a positive impact on the national economy through the human safety. The purification mechanism of pollution from the sarface water and irregation of plants by pure water can save the human from any contigous diseases.

Implementation of the treatment plant one large include all districts of Diwaniyah, When compared with the implementation of the three treatment plants minor cost equal to or slightly more. But we can overcome this problem through the implementation of treatment plants are ready and smaller depending on the number of population in each region. The treatment plants that are currently installed, and will be installed in the future, is a positive and civilized step on the way of environment improvement. These projects have some procautions to environment if no attenetion was paid correctly into consideration. These projects require good management, well staff should be a guardianship and encouraging them the nature of their task.

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Specifications of the standard sewage Service No. 47 of 1988, Iraq.

Appendix (A) Tables

Table (2) The names of districts and its elevation from the sea surface with the length and cost of pipes.

Section	Districts	Elevation (m)	The length of major pipes (m)	The cost of major pipes(1) ($)
1	Al-Naseej House	22.48	3000	525000
	Al-Uroba	23.29	800	140000
	Al-Wahda	23.5	1500	262500
	Al-Motakaden	24.12	1460	255500
	Al- Jumhouri Western	24.01	575	100625
	Al- Jumhouri East	23.9	850	148750
	Al-Iskan Sanay	21.75	1700	297500
	Al-Iskan old	22.02	1736	303800
	Reft	22.84	750	131250
	Aljtah	21.5	1430	250250
	Al-Natha	22.47	1623	284025
	Center City	23.55	2625	459375
2	Al-Forut	22.61	1400	245000
	Al- Saddir	21.75	2900	507500
	Al-Natha 3	22.23	2450	428750
	Al-Jamayh	22.19	1035	181125
	Al-Dhubat	23.02	1385	242375
	Al-Uroba	23.11	1762	308350
	Technical Institute	22.21	813	142275
3	Towards Shamia	22.02	760	133000
	AlZawra'a(Zawra and tadium)	22.07	1500	262500
	University	22.25	2000	350000
	Al-Jazar and Teacher	22.62	1300	227500
	14 Ramadan	22	2350	411250
	Mr. Muhammad House	21.71	2900	507500
	Al-Mechanices	22	3500	612500
	Industrial District	21.27	4000	700000
	Al-Dhubat and Military site	20.43	1462	255850
Total			49566	8674050

Table (3) The number of population and water consumption in each district.

Section	Districts	Number of population *	water consumption** (m^3/day)
1	Al-Naseej House	20250	5062.5
	Al-Uroba	22624	5656
	Al-Wahda	36750	9187.5
	Al-Motakaden	3500	875
	Al- Jumhouri Western	9754	2438.5
	Al- Jumhouri East	11343	2835.75
	Al-Iskan Sanay	4787	1196.75
	Al-Iskan old	11500	2875
	Reft	12000	3000
	Aljtah	13500	3375
	Al-Natha	29180	7295
	Center City	21500	5375
2	Al-Forut	17500	4375
	Al- Saddir	77250	19312.5
	Al-Natha 3	11570	2892.5
	Al-Jamayh	4500	1125
	Al-Dhubat	10954	2738.5
	Al-Uroba	8254	2063.5
	Technical Institute	7500	1875
3	Towards Shamia	500	125
	Al Zawra'a (Zawra and Stadium	27888	6972
	University	2543	635.75
	Al-Jazar and Teacher	9615	2403.75
	14 Ramadan	7600	1900
	Mr. Muhammad House	7700	1925
	Al-Mechanices	1550	387.5
	Industrial District	7800	1950
	Al-Dhubat and Military site	6210	1552.5
Total		405622	101405.5

* Diwaniyah Council Office, Report (2007 and 2008) , Iraq .
** Specifications of the standard sewage Service No. 47 of 1988, Iraq.

Table (4) The result of the 1st solution of the treatment plants (1,2,3)

Variable	Value	Variable	Value	Variable	Value
x_{111}	5062.5	n_1	0	p_1	0.5
x_{211}	5656.0	n_2	0	p_2	0
x_{311}	9187.5	n_3	0	p_3	0
x_{411}	875.0	n_4	0	p_4	0
x_{511}	2438.5	n_5	0	p_5	0
x_{611}	2835.5	n_6	0	p_6	0
x_{711}	1196.5	n_7	0	p_7	0
x_{811}	2875.0	n_8	0	p_8	0
x_{911}	3000.0	n_9	0	p_9	0
$x_{(10)11}$	3375.0	n_{10}	0	p_{10}	0
$x_{(11)11}$	7295.0	n_{11}	0	p_{11}	0
$x_{(12)11}$	5375.0	n_{12}	0	p_{12}	0
x_{122}	4375.0	n_{13}	0	p_{13}	0
x_{222}	19312.5	n_{14}	0	p_{14}	0
x_{322}	2892.5	n_{15}	0	p_{15}	0
x_{422}	1125.0	n_{16}	0	p_{16}	0
x_{522}	2738.5	n_{17}	0	p_{17}	0
x_{622}	2063.5	n_{18}	0	p_{18}	0
x_{722}	1875.0	n_{19}	0	p_{19}	7478.0
x_{133}	125.0	n_{20}	0	p_{20}	0
x_{233}	6972.0	n_{21}	0	p_{21}	0
x_{333}	635.5	n_{22}	0	p_{22}	0
x_{433}	2403.5	n_{23}	0	p_{23}	0
x_{533}	1900.0	n_{24}	0	p_{24}	0
x_{633}	1925.0	n_{25}	0	p_{25}	0
x_{733}	387.5	n_{26}	0	p_{26}	0
x_{833}	1950.0	n_{27}	0	p_{27}	0
x_{933}	1552.5	n_{28}	0	p_{28}	0
		n_{29}	0	p_{29}	311.5
		n_{30}	0	p_{30}	0
		n_{31}	0	p_{31}	27509.5
		n_{32}	0	p_{32}	69446320.0
		n_{33}	0	p_{33}	88260448.0
		n_{34}	0	p_{34}	36421404.0
		n_{35}	0	p_{35}	33970810880.0

Table (5) The result of the 2nd solution of the treatment plants (1,2*,3)

Variable	Value	Variable	Value	Variable	Value
x_{111}	5062.5	n_1	0	p_1	0
x_{211}	5656.0	n_2	0	p_2	0
x_{311}	9187.5	n_3	0	p_3	0
x_{411}	875.0	n_4	0	p_4	0
x_{511}	2438.5	n_5	0	p_5	0
x_{611}	2835.5	n_6	0	p_6	0
x_{711}	1196.5	n_7	0	p_7	0
x_{811}	2875.0	n_8	0	p_8	0
x_{911}	3000.0	n_9	0	p_9	0
$x_{(10)11}$	3375.0	n_{10}	0	p_{10}	0
$x_{(11)11}$	7295.0	n_{11}	0	p_{11}	0
$x_{(12)11}$	5375.0	n_{12}	0	p_{12}	0
x_{122}	4375.0	n_{13}	0	p_{13}	0
x_{222}	19312.5	n_{14}	0	p_{14}	0
x_{322}	2892.5	n_{15}	0	p_{15}	0
x_{422}	1125.0	n_{16}	0	p_{16}	7478.0
x_{522}	2738.5	n_{17}	0	p_{17}	0
x_{622}	2063.5	n_{18}	0	p_{18}	0
x_{722}	1875.0	n_{19}	0	p_{19}	0
x_{133}	125.0	n_{20}	0	p_{20}	0
x_{233}	6972.0	n_{21}	0	p_{21}	0
x_{333}	635.5	n_{22}	0	p_{22}	0
x_{433}	2403.5	n_{23}	0	p_{23}	0
x_{533}	1900.0	n_{24}	0	p_{24}	0
x_{633}	1925.0	n_{25}	0	p_{25}	0
x_{733}	387.5	n_{26}	0	p_{26}	0
x_{833}	1950.0	n_{27}	0	p_{27}	0
x_{933}	1552.5	n_{28}	0	p_{28}	0
		n_{29}	0	p_{29}	311.5
		n_{30}	0	p_{30}	0
		n_{31}	0	p_{31}	27509.5
		n_{32}	0	p_{32}	69446320.0
		n_{33}	0	p_{33}	76898520.0
		n_{34}	0	p_{34}	36421404.0
		n_{35}	0	p_{35}	31982473216.0

Table (6) The result of the 3rd solution of the treatment plants (1,2,3*)

Variable	Value	Variable	Value	Variable	Value
x_{111}	5062.5	n_1	*0*	p_1	*0*
x_{211}	5656.0	n_2	*0*	p_2	*0*
x_{311}	9187.5	n_3	*0*	p_3	*0*
x_{411}	875.0	n_4	*0*	p_4	*0*
x_{511}	2438.5	n_5	*0*	p_5	*0*
x_{611}	2835.5	n_6	*0*	p_6	*0*
x_{711}	1196.5	n_7	*0*	p_7	*0*
x_{811}	2875.0	n_8	*0*	p_8	*0*
x_{911}	3000.0	n_9	*0*	p_9	*0*
$x_{(10)11}$	3375.0	n_{10}	*0*	p_{10}	*0*
$x_{(11)11}$	7295.0	n_{11}	*0*	p_{11}	*0*
$x_{(12)11}$	5375.0	n_{12}	*0*	p_{12}	*0*
x_{122}	4375.0	n_{13}	*0*	p_{13}	*0*
x_{222}	19312.5	n_{14}	*0*	p_{14}	*0*
x_{322}	2892.5	n_{15}	*0*	p_{15}	*0*
x_{422}	1125.0	n_{16}	*0*	p_{16}	0
x_{522}	2738.5	n_{17}	*0*	p_{17}	*0*
x_{622}	2063.5	n_{18}	*0*	p_{18}	0
x_{722}	1875.0	n_{19}	*0*	p_{19}	*7478.0*
x_{133}	125.0	n_{20}	*0*	p_{20}	*0*
x_{233}	6972.0	n_{21}	*0*	p_{21}	*0*
x_{333}	635.5	n_{22}	*0*	p_{22}	*0*
x_{433}	2403.5	n_{23}	*0*	p_{23}	*0*
x_{533}	1900.0	n_{24}	*0*	p_{24}	*0*
x_{633}	1925.0	n_{25}	*0*	p_{25}	*0*
x_{733}	387.5	n_{26}	*0*	p_{26}	*0*
x_{833}	1950.0	n_{27}	*0*	p_{27}	*0*
x_{933}	1552.5	n_{28}	*0*	p_{28}	*0*
		n_{29}	*0*	p_{29}	*311.5*
		n_{30}	*0*	p_{30}	*0*
		n_{31}	*0*	p_{31}	*27509.5*
		n_{32}	*0*	p_{32}	*69446320.0*
		n_{33}	*0*	p_{33}	*88260448.0*
		n_{34}	*0*	p_{34}	*29307424.0*
		n_{35}	*0*	p_{35}	*32302030848.0*

Table (7) The result of the 4th solution of the treatment plants (1,2*,3*)

Variable	Value	Variable	Value	Variable	Value
x_{111}	5062.5	n_1	0	p_1	0
x_{211}	5656.0	n_2	0	p_2	0
x_{311}	9187.5	n_3	0	p_3	0
x_{411}	875.0	n_4	0	p_4	0
x_{511}	2438.5	n_5	0	p_5	0
x_{611}	2835.5	n_6	0	p_6	0
x_{711}	1196.5	n_7	0	p_7	0
x_{811}	2875.0	n_8	0	p_8	0
x_{911}	3000.0	n_9	0	p_9	0
$x_{(10)11}$	3375.0	n_{10}	0	p_{10}	0
$x_{(11)11}$	7295.0	n_{11}	0	p_{11}	0
$x_{(12)11}$	5375.0	n_{12}	0	p_{12}	0
x_{122}	4375.0	n_{13}	0	p_{13}	0
x_{222}	19312.5	n_{14}	0	p_{14}	0
x_{322}	2892.5	n_{15}	0	p_{15}	0
x_{422}	1125.0	n_{16}	0	p_{16}	7478.0
x_{522}	2738.5	n_{17}	0	p_{17}	0
x_{622}	2063.5	n_{18}	0	p_{18}	0
x_{722}	1875.0	n_{19}	0	p_{19}	0
x_{133}	125.0	n_{20}	0	p_{20}	0
x_{233}	6972.0	n_{21}	0	p_{21}	0
x_{333}	635.5	n_{22}	0	p_{22}	0
x_{433}	2403.5	n_{23}	0	p_{23}	0
x_{533}	1900.0	n_{24}	0	p_{24}	0
x_{633}	1925.0	n_{25}	0	p_{25}	0
x_{733}	387.5	n_{26}	0	p_{26}	0
x_{833}	1950.0	n_{27}	0	p_{27}	0
x_{933}	1552.5	n_{28}	0	p_{28}	0
		n_{29}	0	p_{29}	311.5
		n_{30}	0	p_{30}	0
		n_{31}	0	p_{31}	27509.5
		n_{32}	0	p_{32}	69446320.0
		n_{33}	0	p_{33}	76898520.0
		n_{34}	0	p_{34}	29307424.0
		n_{35}	0	p_{35}	30737235968.0