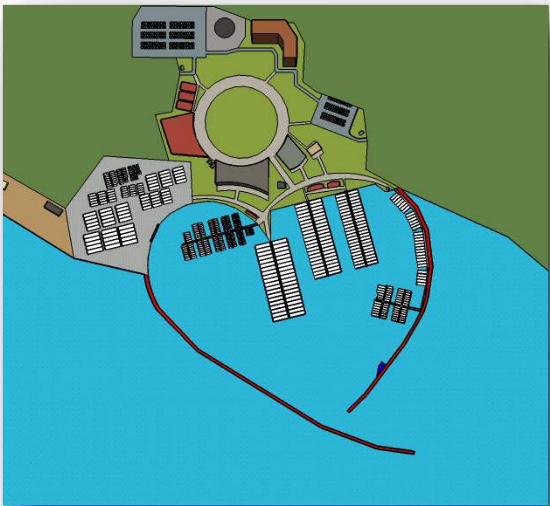

CE 496

MARINAS

Final Report

ABSTRACT

Due to the insufficient berthing facilities along Mediterrean coasts, idea of constructing a new marina on Fethiye region is came up to scene, which is named as Marine Fellowship. This marina has a total capacity for 546 yachts, 396 at sea and 150 at land. This report consists of all details of the Fellowship Marina including both structural and management side.

Alpay Burak Demiryürek

Uğurcan Özdemir

FELLOWSHIP – II

Mediterrenean Region

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INTRODUCTION

Aegean bowl has a marine tourism potential for 500,000 yachts and boats. However, existing marinas in Turkish Coasts are not adequate to get striking profit from that potential. Thus, the depend of a new marina facility is bornt as a consequence of that fact. An investigation over Fethiye coasts is requested by authorities to determine most suitable place for the new marina facility. In this context, as a preliminary work, two alternative locations were chosen and evaluated with respect to logical, technical and non-technical scale.

There can be categorized some matters to be considered in initial site assessment. Under these categorization, it is worked to answer some questions for every alternatives.

- **Operational Requirements**
  - Does the site provide sufficient land area for present and future requirements?
  - Is this an efficient site relative to the market?
  - Can services be efficiently supplied to the site (e.g power, water)?
  - Is the design depth available for the construction?
- **Topographic & Meteorological Assessment**
  - Are the rainfall patterns or prevailing wind directions likely to cause management difficulties?
- **Water Issues**
  - Are there any site constraints which make on-site water management difficult (including both process water and storm water)?
  - Are there risks of surface water pollution because of the proximity or pathways to water bodies?
  - Are there risks of groundwater pollution because of shallow or rising groundwater tables, or proximity to groundwater recharge areas, or areas with a high vulnerability to pollution? (This will require consultation with the Department of Land and Water Conservation)
  - Is the site susceptible to flooding?
  - Will regular maintenance dredging be required?
- **Geological or Soil Issues**
  - Are there any topography or geological characteristics which will cause difficulties in managing impacts (subsidence, slippage, seismic)?
  - Are the soils highly erodible? Identify any potential sediment management problems.
  - Is bank erosion likely?
  - Are there existing soil problems (e.g. contaminated soils, acid sulfate or saline soils)?
- **Transport Issues**
  - Is there any pavement exists in order to connect the marina to towns?

- Is it easy to access nearest airport?
- Are there parking or access constraints?

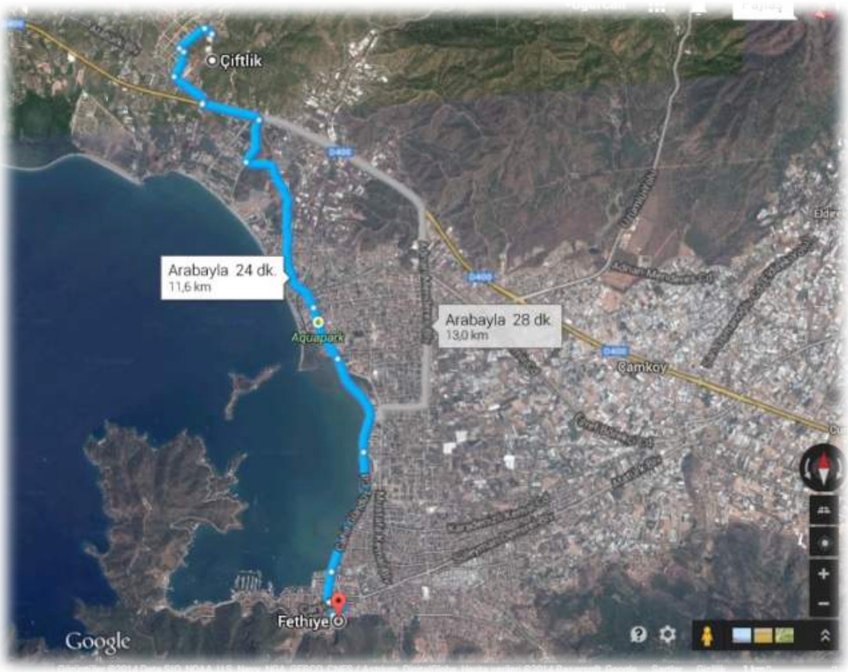
- **Community Issues**
  - Will nearby aquaculture, fish breeding or fishing grounds be affected?
  - Is the proposal likely to affect the heritage significance of any Aboriginal or non-Aboriginal heritage items found or likely to be found on the site?
  - Is the site highly visible? Will there be significant visual impacts?
  - Will access to public land or waterways be restricted?

SITE SELECTION

Site selection is an important step during the preliminary marine design. Due to the fact that, there are many concerns which should be considered before designing structural aspects of the marina. If any important point is missed out in this step, it would lead tough situation on which spend a lot of time.

ALTERNATIVE LOCATIONS

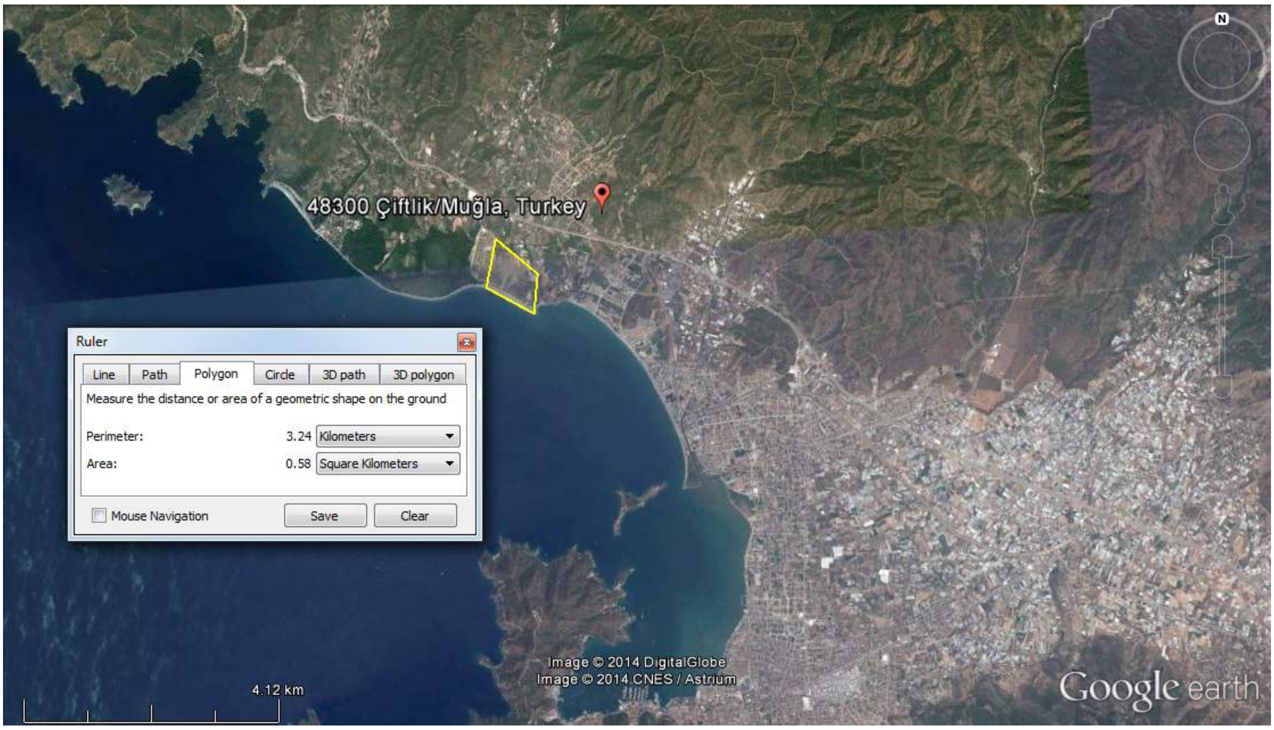
ALTERNATIVE– I – FETHIYE – CIFTLIK



Çiftlik is located at the state of the Muğla and county of the Fethiye. It is around 12 kilometers away from the Fethiye being very significant property of construction marina which is adjacency of the central town. It takes nearly half an hour reaching the Fethiye from the Çiftlik with car. The coordinates of the planned alternative marina 1 is 36°15'41.93"N and 29°22'7.69"E.

Operational Requirements

The land area of the construction site of the marina is nearly about 0.6 kilometers square and it indicates there is enough space to construct a marina with respect to land area. For initial guess, roughly 1 kilometer square area including both sea and land (0.5 kilometer square for land and 0.5 kilometer square for sea) is determined and looks forward this area for the considered place. For rubble mound breakwater, quarry stones are going to be produced at the Denizli and also Antalya at where a lot of quarry stone companies is located. There is enough site space in order to set up ready-mix concrete station if necessary. The site location is very close to the Fethiye and Settlement of the Çiftlik; therefore, it is not healthy deduction for lack of need for electricity and water. In addition, the water depth of the marine border changes the range between 3 – 7 meter.



Meteorological Assessment

From the Turkish State Meteorological Service, between 1960 and 2012 years, the most amount of the rainfall in a day is 168.8 kg/m^2 in 10.10.2011, the fastest wind velocity is 108.7 km/hr in 18.02.1968 and the highest snow is 25 cm in 24.02.1985. When going into details of the monthly average statistics of the values, it can be concluded as meteorological issues does not affect both construction and management of the marina.

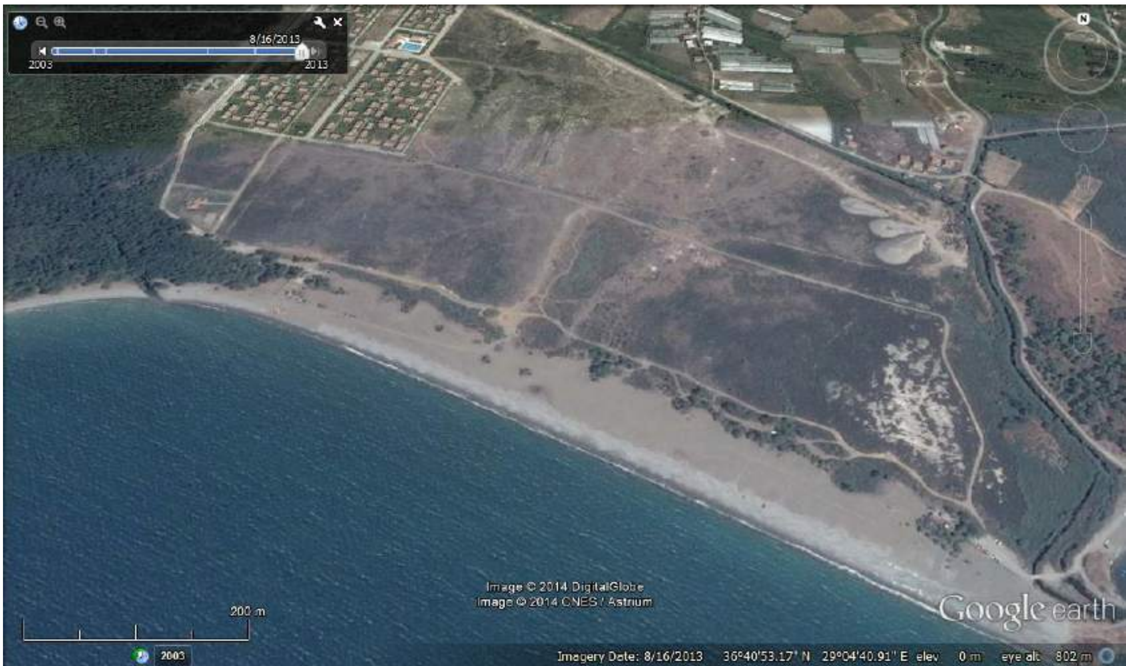
Water Issues

Since the construction site is very close to the town, there will not be any problem occurred regarding the excess of process or storm water thanks to sewage systems of the towns. To point out the groundwater level, there is not any information or measurement from the site; however, it can be assumed the marina cannot be very harmful on the groundwater because, instead of the Fethiye marina which is nearly 12 kilometer away from the alternative marina site, there is no other marina which affects the groundwater cleanliness and level. The region is not susceptible to the flooding according to Turkish State Meteorological Service. However, breakwater can be necessary for the marina after the calculation of fetch area and wind velocity calculations. Around the planned site area, there is not any river resulting in filling and erosion exist and so regular maintenance dredging will not be required.

Geological or Soil Issues

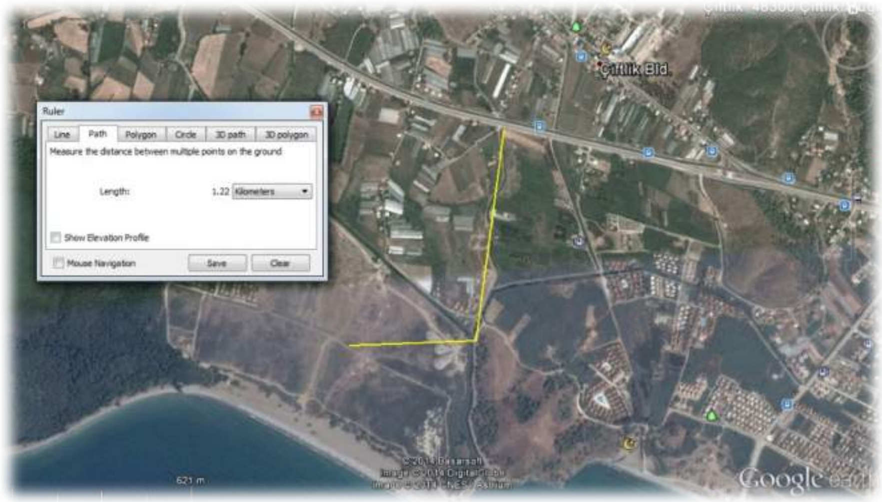
When the topographic situation is considered, there will not any possible problems facing with during the construction since the location where the possible marine construction area is not placed at the mountainous area and placed generally smooth and plain area. This is another important factor for constructing a marine due to the decreasing the earthwork such as excavating and so decreases the cost of the project. Another significant thing if the marine is constructed at the mountainous area is difficulty of the pavement construction which is connecting the main road.

Another thing is that although the region that the marina will be constructed at is placed at the first degree earthquake zone, the marina will not be affected the impacts due to the earthquake.

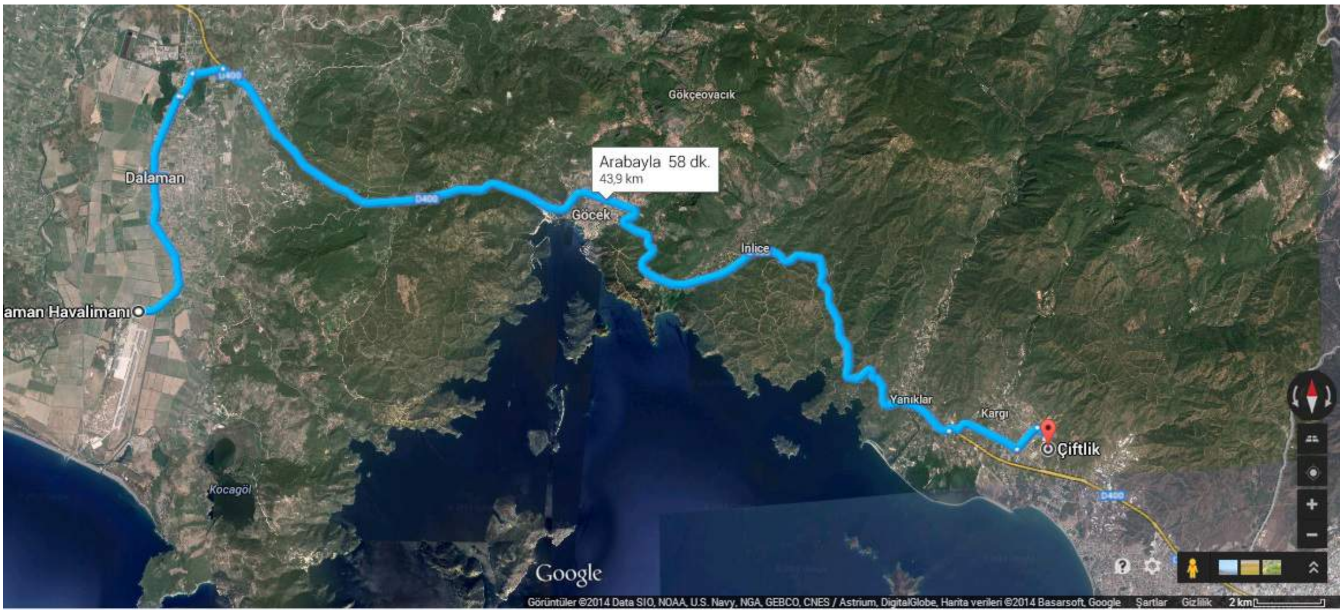


The neighborhoods of the planned marina site does not consist of any river resulting in erodible soil.

Transport Issues



One feature that makes the marina valuable is distance between marina and main pavement to connect the marina to the city or town. The distance between marina and D400 highway is nearly about 1 kilometer length. This situation makes the marina very easily access to the Çiftlik and so Fethiye. If the nearest airport distance is considered, it is concluded as the Dalaman Airport is around 45 kilometer away from the marina place, Çiftlik. Last thing with the aspect of transport issues is parking area. As indicated from the operational requirements, there is around 0.6 kilometer square land available for the marina; therefore, some part of this area can be enough to use parking.



Community Issues

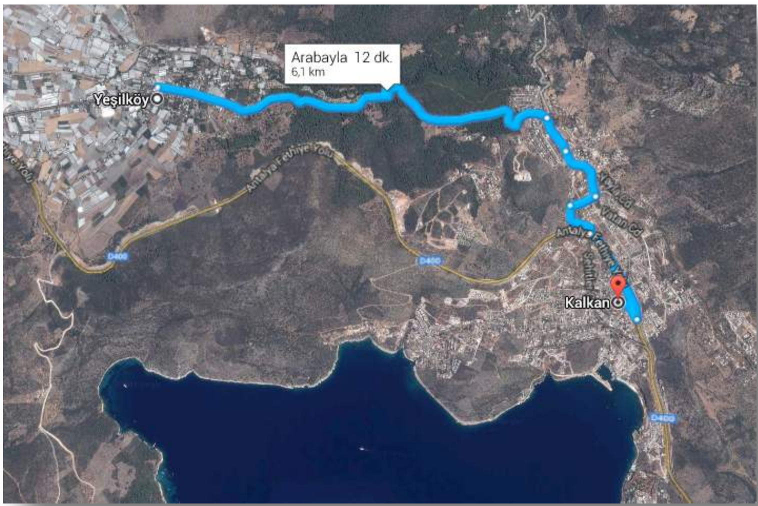
For fishing industry, this planned marina can affect existing fishing activities because Fethiye marina is not far away from the planned marina. However, the only existing marina at Fethiye is Fethiye marina, and constructed new marina can attract the fishing industry. Therefore, constructing this marina is not going to affect badly to the fishing industry.

Muğla is a place where testify a lot of historical events; therefore, during the construction historical heritage such as ruins, books etc. can be faced. However, this is not a problem of constructing a marina, just delaying reasons during the construction of the marina.

The marina does not hide behind the bay and it is almost open to all south directions. Therefore, aesthetics is getting more important for designing part due to the site being highly visible.

This marina will not restrict to access public land or waterways. On the contrary, this planned marina makes the Çiftlik getting developed due to the interaction with the Fethiye.

ALTERNATIVE – II– KALKAN– FIRNAZ COVE



Fırnaz Cove is placed at 8 kilometers away from the Kalkan. The nearest settlement from the alternative marine II is Yesilkoy. Yesilkoy is not sophisticated place; however, it is very suitable to advance. The distance between Yesilkoy and Kalkan is nearly about 7 kilometers. The coordinates of the planned alternative marina 2 is 36°15'41.93"N and 29°22'7.69"E.

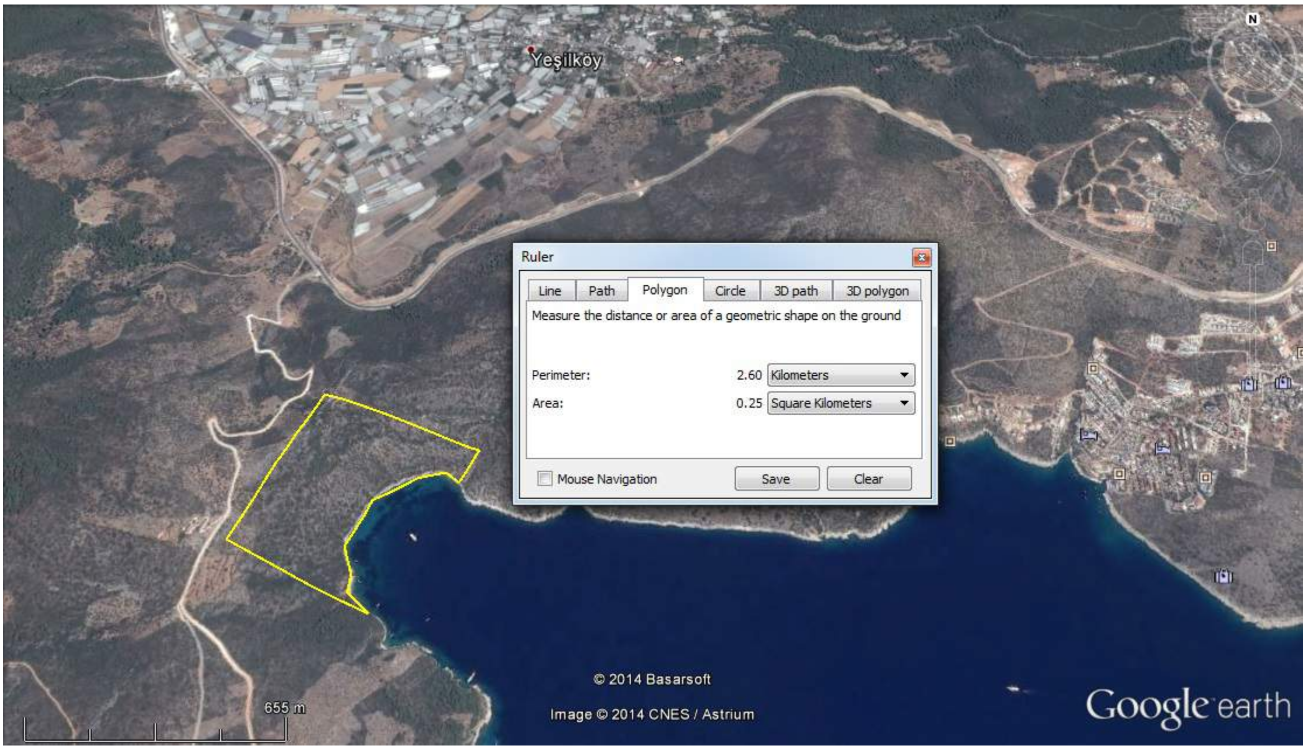
Operational Requirements

The planned marina site is determined as around 0.25 kilometer square area for land use without fill work. For initial site selection, 0.5 kilometer square area can be determined for any need of the space for land use. However, with the earth fill work from the dredging the sea for reaching the design depth can make suitable area for land use.

Antalya is available place for quarry stone companies in order to construct rubble mound breakwater and so quarry stone market is not far away from the Kalkan; in other words, planned alternative marina site 2. For site mobilization, it has to be some extra place due to the lack of the land area.

Likewise Fethiye Çiftlik, Fırnaz Cove is close to the Kalkan which is big county comparing to the nearest counties. Thanks to Kalkan, services can be efficiently supplied to the site.

Last thing of operational requirements is that the water depth of the marine border is 77 meter which is the most negative effect.



Meteorological Assessment

From the Turkish State Meteorological Service, at Antalya, between 1960 and 2012 years, the most amount of the rainfall in a day is 331.5 kg/m^2 in 17.01.1969, the fastest wind velocity is 155.5 km/hr in 22.01.1998 and the highest snow is 5 cm in 07.01.1993. When going into details of the monthly average statistics of the values, it can be concluded as meteorological issues does not affect both construction and management of the marina.

Water Issues

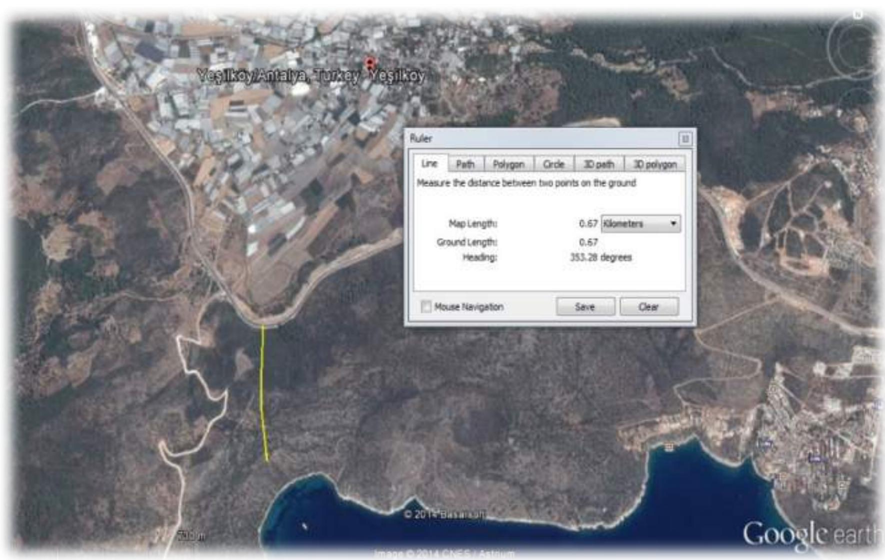
When Kalkan which is very close to county to the planned marina site is compared to the Fethiye, the population of the Kalkan is less than the Fethiye and so sewage system is designed for low population. After the construction marina, new settlement facilities will be placed near the marina and the sewage system cannot afford the population with new settlements and there will be a need for new treatment plant and sewage system for both process water and storm water.

Another important issue is the risk of surface water pollution. However, there is nothing about to worry this issue due the minority of the marinas at this region. There is only Kalkan marina exists at this region.

Geological or Soil Issues

The planned marina site at the Fırnaz Cove is located at the mountainous region up to 150 meter altitude. One option is replacing from the excavating earth work from the land to filling higher depth of the sea. Due to lack of river around the marina site, it is not a chance to be erodible soil at the marina site. One drawback of the marina site with respect to geological side, there are a lot of tree at the mountainous region.

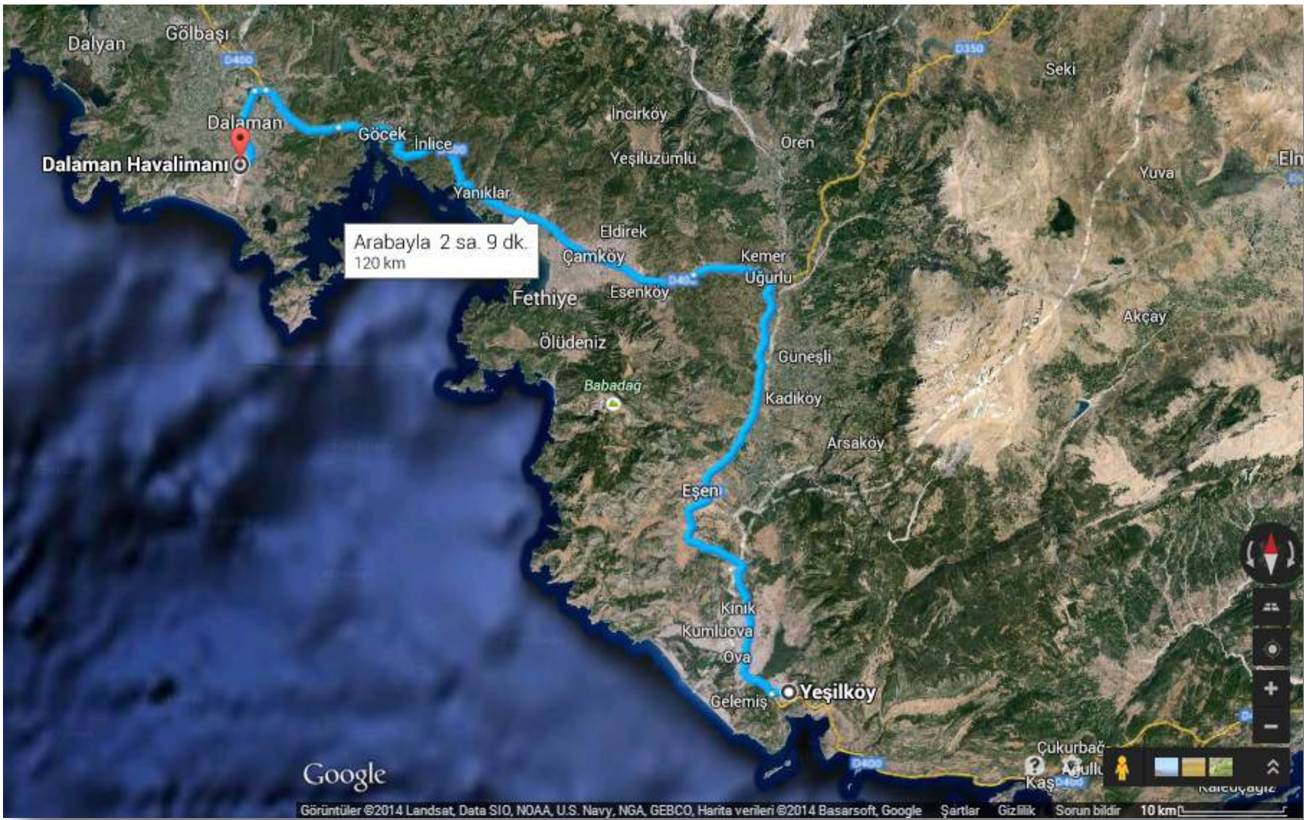
Transport Issues



The planned marina site is nearly 1 kilometer away from the D400 Antalya Fethiye Pavement. There is no extra road construction needed and it leads to lower cost of designing and construction of new pavement in order to connect marina to towns.

There are two options for accessing the closest airport from the Yesilkoy. One is Dalaman Airport similarly Fethiye Çiftlik marine alternative and second one is the Antalya Airport. Comparing each of them, Antalya

Airport is 246 km away from the Yesilkoy and Dalaman Airport is 120 km away from the marina site. Both of them take more distance comparing with the Fethiye Çiftlik marina site.



Although the site does not consist of any settlement and available for new facilities, the ground profile is mountainous and therefore, there are not any parking constraints if the land is excavated until reaching the plain profile.

Community Issues

Instead of the Fırnaz Cove marina alternative, there only exists Kalkan marina. Considering this situation, the center of the fishing activities is around the Kalkan marina.

After this marina will be constructed, the fishing activities may increase and competition in fishing activities is getting better after the marina construction at the Fırnaz Cove.

The site is not highly visible due to the fact that the marina hide behind the cove. In addition, the planned marina will not be restricted to access to any public land or waterways.

CONCLUSION AND DISCUSSIONS

Due to the Aegean Region that we work on, there are a lot of mountainous and protected area exists for the construction of marina; therefore, there are only two alternatives selected and evaluated in very detailed.

In order to choose one of the alternatives of the marina, the matrix system can be established and can be used defined scoring system. Matrix system can consist of the criteria's being used during the evaluation of the marinas. In addition, grading system could be out of 5(five). 5 means that it is very suitable for constructing marina with respect to this criteria. The less point the criteria takes, the less available the marina will construct at this place.

		Alternative 1 Fethiye Çiftlik	Alternative 2 Kalkan Fırnaz Cove
Technical Reasons	Operational Requirements	5	4
	Geological or Soil Issues	4	2
	Meteorological Assessment	5	5
Non-Technical Reasons	Water Issues	5	5
	Transport Issues	5	4
	Community Issues	4	3

We have developed a rating system with an overall score of 30 pts. For our rating system, we have given the 60% of the general score to technical reasons and 40% to the non-technical reasons. In both category, sub categories have an influence factor of maximum 3 and minimum 1, from the upper to lower subcategory, i.e Operational requirements has a multiplier 3 whereas Meteorological Assesment's 1. According to this rating system, alternative 1 has a gpa of 28.4/30 and alternative 2 has a gpa of 23/30.

To conclude the matrix system, it is very clear to observe that Fethiye Çiftlik marina site is more suitable than Kalkan Fırnaz Cove with respect to sum of different criteria's.

FETCH COMPUTATIONS

In lights of the investigations done in site selection step, we have selected the Fethiye – Çiftlik region to locate our marina. For this step of the project, we have requested to prepare the fetch distances for that project site and also to write a computer program/code for wave hindcasting.

FETCH DISTANCES

The fetch, also called the fetch length, is the length of water over which a given wind has blown. Fetch is used in geography and meteorology and its effects are usually associated with sea state and when it reaches shore it is the main factor that creates storm surge which leads to coastal erosion and flooding. It also plays a large part in longshore drift as well.

The main three factors that work together to create waves are:

- Wind speed
- Length of time the wind has blown
- Distance of open water that the wind blows over; called *fetch*

Each of these factors play a part in creating waves. The greater any of the variables in the equation, the greater the waves. Fetch length along with the wind speed (wind strength) determines the size (sea state) of waves produced. The wind direction is considered constant. The longer the fetch and the faster the wind speed, the more wind energy is imparted to the water surface and the larger the resulting sea state will be. However, in reality wind direction is not constant and changes in wind direction can be problematic, since changes in wind direction cause multiple wave systems to emerge. As these systems collide, they multiply, inevitably causing larger waves. Thus, effective fetch concept is developed to handle this situation. Effective fetch calculation involves the measurement of the fetch distance along several directions from a given point from the shore and is a standard engineering measurement for shore protection studies. In our practice we have taken 22.5^{o} from each side of the selected direction with an increment/decrement of 7.5^{o}.

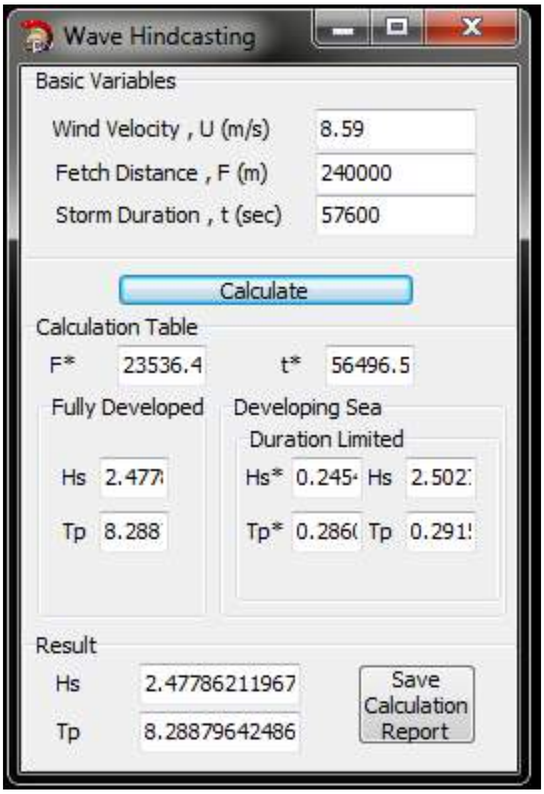
Two different scaled site maps are used to get fetch distances for the sake of clearness in views. Both maps used in determining fetch distances can be categorized as “Large Scale Maps”. Directions which are taken into consideration and calculated effective fetch distances are listed below in Table 1.1. Related *.dwg files and *.xls files will be submitted with this report as appendices.

Direction	Calculated Effective Fetch (km)
SSW	681.9999638
SW	460.1361735
WSW	251.4043664
W	12.94387922
WNW	10.84597958
NW	8.068398611
NNW	4.047855991
S: South , N : North , W : West	

TABLE 1.1

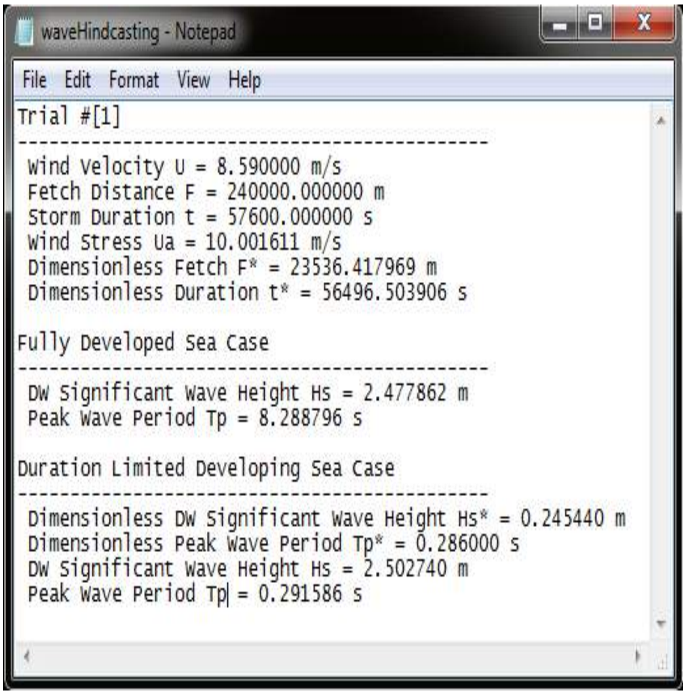
Since the effective fetch distances are getting smaller, when compared to SSW direction, effective fetch lengths of other directions are not taken into consideration.

COMPUTER PROGRAM



A visual computer program which takes wind velocity, fetch distance and storm duration as input parameters for wave hindcasting is written in C language with Embarcadero Rad Studio. Those source codes and the executable file will also be added as appendices. A screenshot of the program and the result of the trial according to Hasselman's nomogram is shown at left.

For this example, fetch length is taken as 240 km (240,000 meters), storm duration 16 hours (16*60*60 = 57,600 secs) and the wind velocity 8,59 m/s. Saved report format is also shown at right.



WIND WAVE ANALYSIS

Wind wave data collected from the appropriate nearby stations for the fetch distances (directions) which are computed in project work step II. For this step of the project, we have requested to perform long term statistics of given data to determine dominant wave direction, deep water significant wave heights and periods and also to perform extreme term statistics to come up with 50 and 100 year deep water significant wave heights.

LONG TERM STATISTICS

For the Fethiye – Çiftlik site, waves approach from three different directions (SSW, SW and WSW). Long term wave analyses are performed for each direction.

SSW DIRECTION

SSW						
m	H_{so}	f	Q	y=ln(Q)	H_{so}*y	y^2
1	0	53604	0.218542	-1.520777	0	2.312762
2	0.4	40708	0.165965	-1.795976	-0.71839	3.225529
3	0.8	31666	0.129101	-2.047157	-1.63773	4.190851
4	1.2	24537	0.100037	-2.302218	-2.76266	5.300209
5	1.6	19146	0.078058	-2.550307	-4.08049	6.504064
6	2	15451	0.062993	-2.764727	-5.52945	7.643714
7	2.4	12493	0.050934	-2.977232	-7.14536	8.86391
8	2.8	10305	0.042013	-3.169771	-8.87536	10.04745
9	3.2	8365	0.034104	-3.378344	-10.8107	11.41321
10	3.6	6858	0.02796	-3.576985	-12.8771	12.79482
11	4	5510	0.022464	-3.795836	-15.1833	14.40837
12	4.4	2547	0.010384	-4.567484	-20.0969	20.86191
13	4.8	1210	0.004933	-5.31178	-25.4965	28.21501
14	5.2	592	0.002414	-6.026649	-31.3386	36.3205
15	5.6	246	0.001003	-6.904824	-38.667	47.6766
16	6	97	0.000395	-7.835445	-47.0127	61.39419
17	6.4	54	0.00022	-8.421172	-53.8955	70.91613
SUM	**54.4**	**233389**	**0.951521**	**-68.94668**	**-286.128**	**352.0892**
AVG	**3.2**	**13728.76**	**0.055972**	**-4.055687**	**-16.8311**	**20.71113**
TOT. HRS	**245280**					

$$\frac{A}{2.3} = \frac{\sum(H_{s0,LL} * y) - m_{max} * \bar{H}_{s0,LL} * \bar{y}}{\sum y^2 - \frac{(\sum y)^2}{m_{max}}} = \frac{(-286.128) - 17 * 3.2 * (-4.05569)}{352.0892 - \frac{68.9467^2}{17}} = -0{,}90389$$

$$B = \bar{H}_{s0,LL} - \bar{y} * \left(\frac{A}{2.3}\right) = 3.2 - (-4.05569) * (-0.90389) = -0.46590$$

Equation of the best fit curve of the distribution: **H_{s0} = -0.90389 x ln[Q(H_{s0}>H')] – 0.46590**

The wave height which can occur 10 hours/year computed from above equation since it is required to be used for designing the layout and computing agitation inside the harbour.

$$H_{s0} = -0{,}90389 * \ln\left(\frac{10}{365 * 24}\right) - 0{,}46590 = 5.65829 \approx 5{,}66\ m$$

Plotted H_s vs Q(<H_s) on normal-normal paper

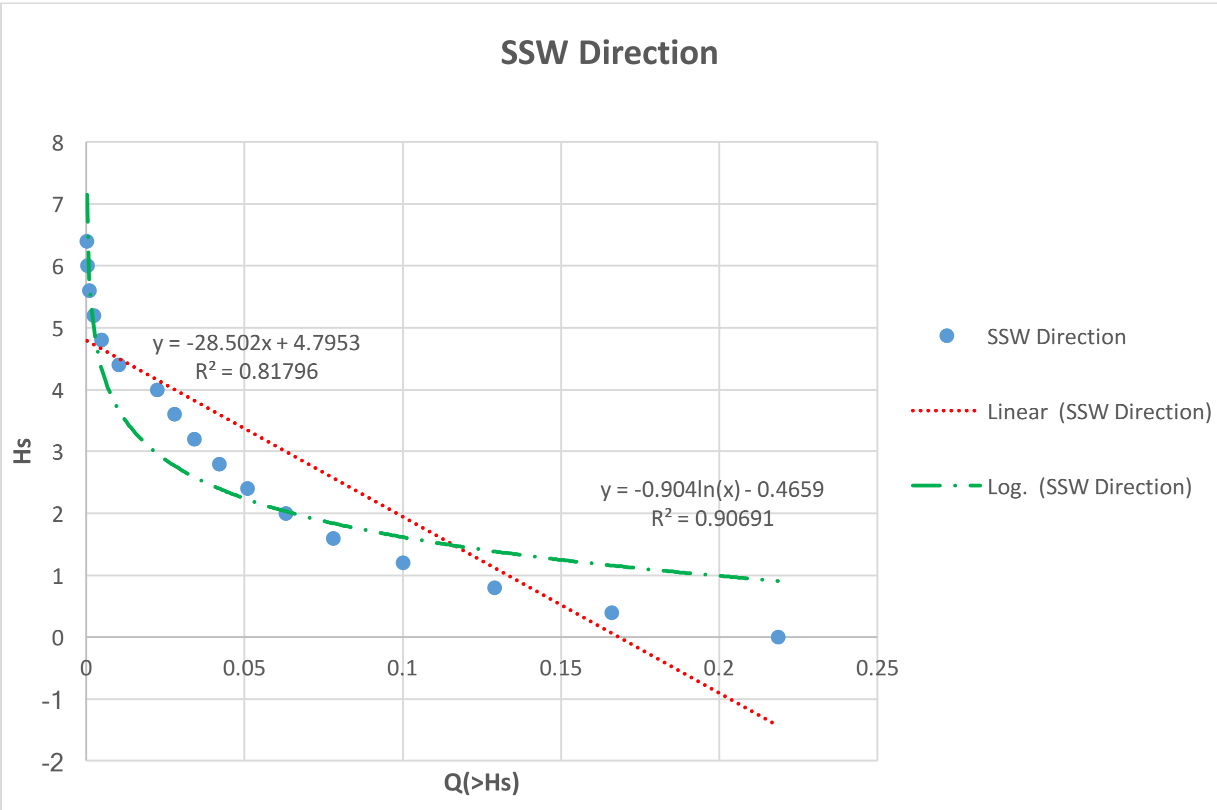


FIGURE 1 : NORMAL – NORMAL PAPER WITH H_S AND Q(>H_S)

As observed in Figure 1, it is not appropriate to fit a linear trendline to wave data drawn on normal-normal paper since regression coefficient (R^2) is 0.818 which is far away from 1.

Plotted H_s vs ln(Q(<H_s)) on normal-normal paper

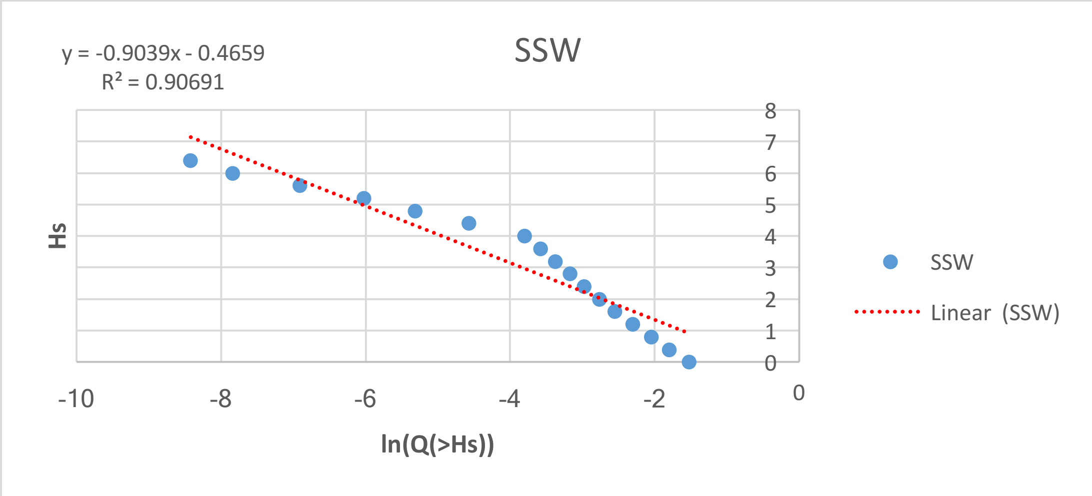


FIGURE 2: NORMAL-NORMAL PAPER WITH H_S VS LN(Q)

To linearize the given data, taking natural logarithms of given exceedance probabilities H_s vs ln(Q(<H_s)) graph is drawn. It can be observed that the logarithmic trendline equation in Figure 1 and the linear trend line in above Figure 2 have same equations and R^2 values.

Plotted H_s vs Q(<H_s) on Log-normal paper

Drawing H_s vs Q(<H_s) data on a log-normal paper is another option to express the relation between them. By fitting a logarithmic trendline to plotted data points it can be noticed that the equation of the trend line and R^2 of it exactly same as above mentioned function in Figure 1 and Figure 2.

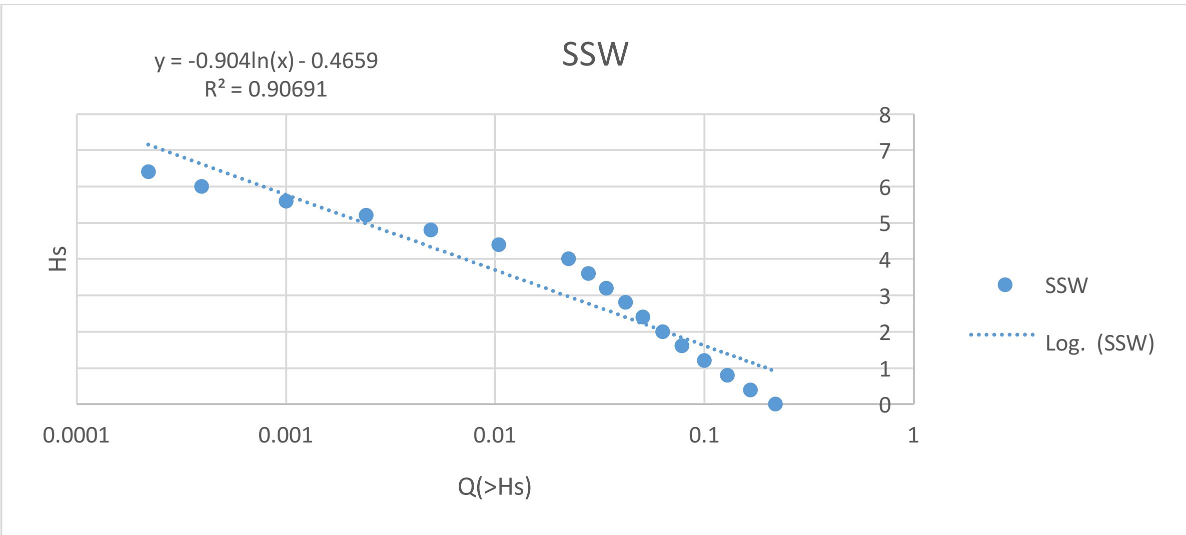


FIGURE 3: LOG-NORMAL PAPER WITH H_S AND Q(>H_S)

SW DIRECTION

SW						
m	H_{so}	f	Q	y=ln(Q)	H_{so}*y	y^2
1	0	29521	0.120356	-2.117299	0	4.482953
2	0.4	26026	0.106107	-2.243304	-0.89732	5.032415
3	0.8	16494	0.067246	-2.699404	-2.15952	7.286781
4	1.2	9926	0.040468	-3.207243	-3.84869	10.28641
5	1.6	5628	0.022945	-3.774646	-6.03943	14.24795
6	2	2629	0.010718	-4.535797	-9.07159	20.57345
7	2.4	1072	0.004371	-5.432874	-13.0389	29.51612
8	2.8	417	0.0017	-6.377069	-17.8558	40.66702
9	3.2	74	0.000302	-8.106091	-25.9395	65.7087
10	3.6	4	1.63E-05	-11.02386	-39.6859	121.5255
SUM	**18**	**91791**	**0.374229**	**-49.51759**	**-118.537**	**319.3273**
AVG	**1.8**	**9179.1**	**0.037423**	**-4.951759**	**-11.8537**	**31.93273**
TOT. HRS	**245280**					

$$\frac{A}{2.3} = \frac{\sum(H_{s0,LL} * y) - m_{max} * \bar{H}_{s0,LL} * \bar{y}}{\sum y^2 - \frac{(\sum y)^2}{m_{max}}} = \frac{(-118.537) - 10 * 1.8 * (-4.95176)}{319.3273 - \frac{49.5176^2}{10}} = -0,39668$$

$$B = \bar{H}_{s0,LL} - \bar{y} * \left(\frac{A}{2.3}\right) = 1.8 - (-4.95176) * (-0.39668) = -0.16426$$

Equation of the best fit curve of the distribution: **H_{s0} = -0.39668 x ln[Q(H_{s0}>H')] – 0.16426**

The wave height which can occur 10 hours/year computed from above equation since it is required to be used for designing the layout and computing agitation inside the harbour.

$$H_{s0} = -0,39668 * \ln\left(\frac{10}{365 * 24}\right) - 0,16426 = 2.52339 \approx 2,52\ m$$

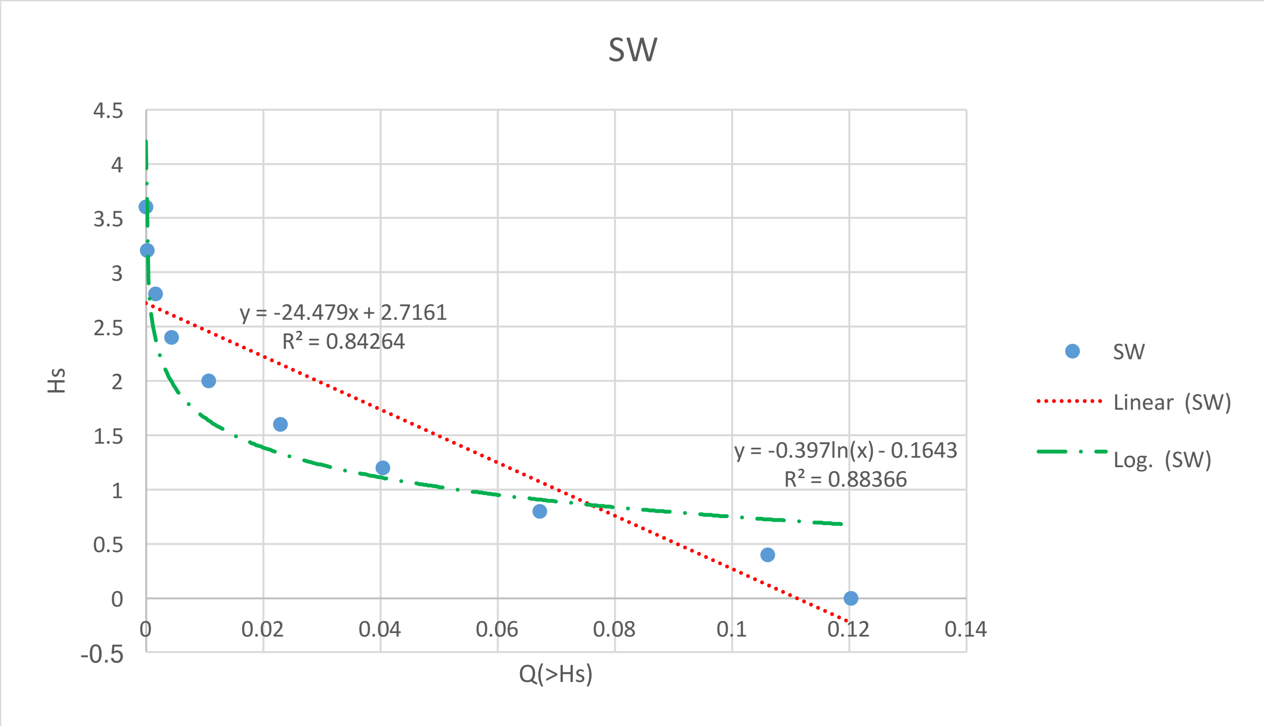


FIGURE 4: NORMAL – NORMAL PAPER WITH H_S AND Q(>H_S)

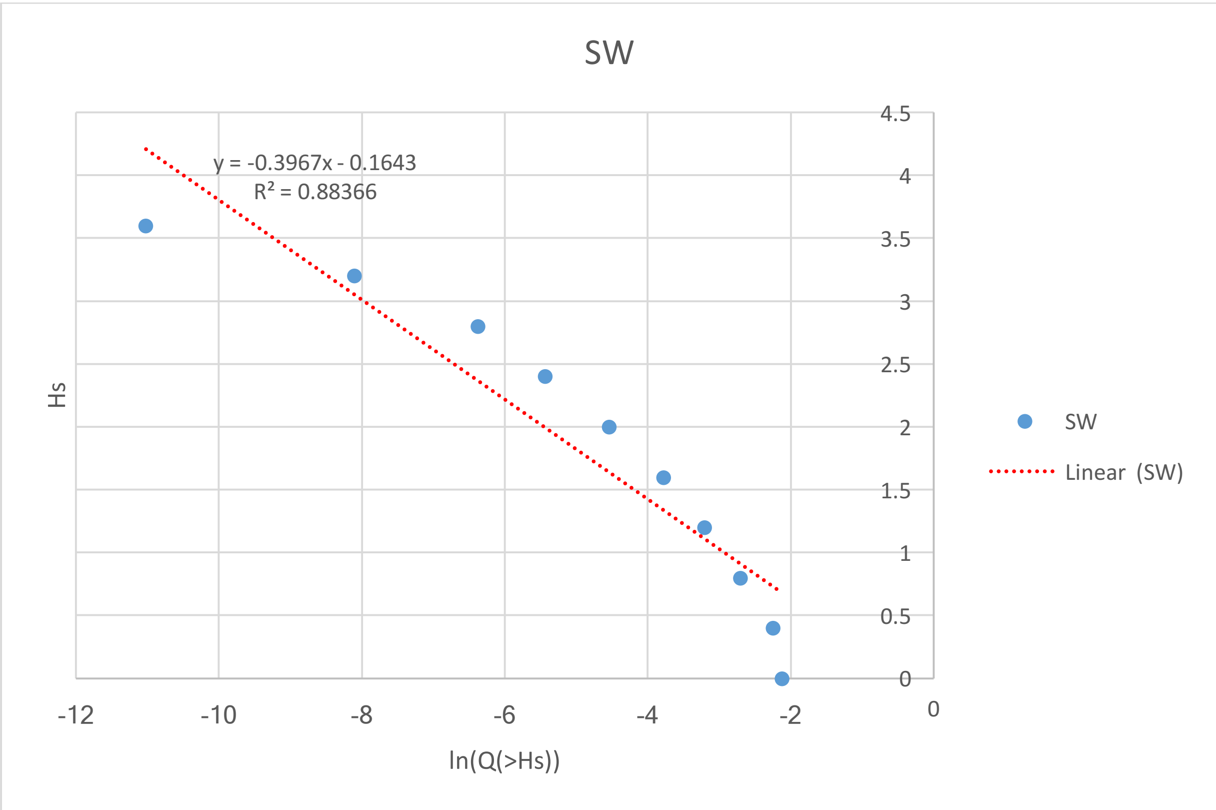


FIGURE 5: NORMAL-NORMAL PAPER WITH H_S VS LN(Q)

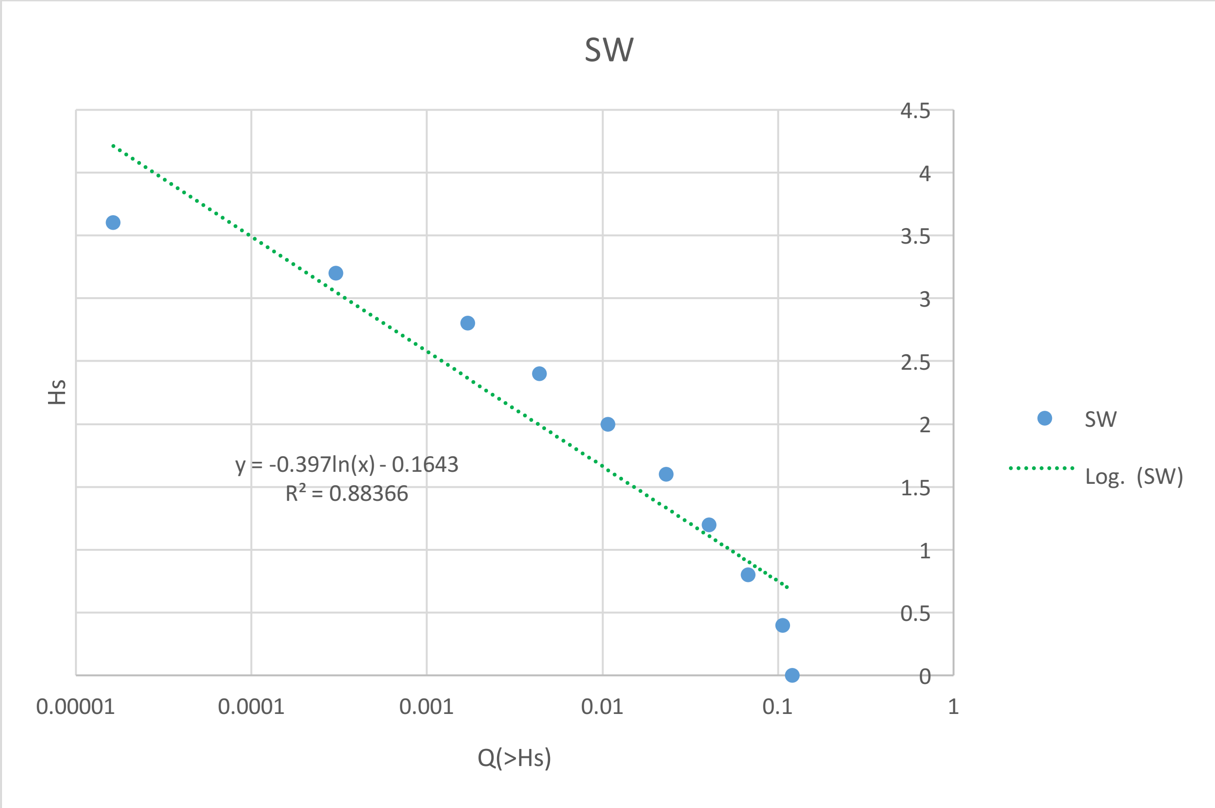


FIGURE 6: LOG – NORMAL PAPER WITH H_S AND $Q(>H_S)$

WSW DIRECTION

WSW						
m	H_{so}	f	Q	y=ln(Q)	H_{so}*y	y^2
1	0	6968	0.028408	-3.561072	0	12.68124
2	0.4	6194	0.025253	-3.678819	-1.47153	13.53371
3	0.8	3707	0.015113	-4.192177	-3.35374	17.57435
4	1.2	1674	0.006825	-4.987184	-5.98462	24.87201
5	1.6	811	0.003306	-5.711888	-9.13902	32.62566
6	2	377	0.001537	-6.477911	-12.9558	41.96332
7	2.4	228	0.00093	-6.98081	-16.7539	48.73171
8	2.8	157	0.00064	-7.35391	-20.5909	54.07999
9	3.2	91	0.000371	-7.899296	-25.2777	62.39888
10	3.6	25	0.000102	-9.19128	-33.0886	84.47963
11	4	17	6.93E-05	-9.576942	-38.3078	91.71782
12	4.4	11	4.48E-05	-10.01226	-44.0539	100.2454
13	4.8	5	2.04E-05	-10.80072	-51.8434	116.6555
14	5.2	4	1.63E-05	-11.02386	-57.3241	121.5255
SUM	**36.4**	**20269**	**0.082636**	**-101.4481**	**-320.145**	**823.0847**
AVG	**2.6**	**1447.786**	**0.005903**	**-7.246295**	**-22.8675**	**58.79176**
TOT. HRS	**245280**					

$$\frac{A}{2.3} = \frac{\sum(H_{s0,LL} * y) - m_{max} * \overline{H}_{s0,LL} * \bar{y}}{\sum y^2 - \frac{(\sum y)^2}{m_{max}}} = \frac{(-320.145) - 14 * 2.6 * (- - 7.24629)}{823.0847 - \frac{101.448^2}{14}} = -0{,}64095$$

$$B = \overline{H}_{s0,LL} - \bar{y} * \left(\frac{A}{2.3}\right) = 2.6 - (-7.24629) * (-0.64095) = -2.04451$$

Equation of the best fit curve of the distribution: **H_{s0} = -0.64095 x ln[Q(H_{s0}>H')] – 2.04451**

The wave height which can occur 10 hours/year computed from above equation since it is required to be used for designing the layout and computing agitation inside the harbour.

$$H_{s0} = -0{,}64095 * \ln\left(\frac{10}{365 * 24}\right) - 2.04451 = 2{,}29816 \approx 2{,}3\ m$$

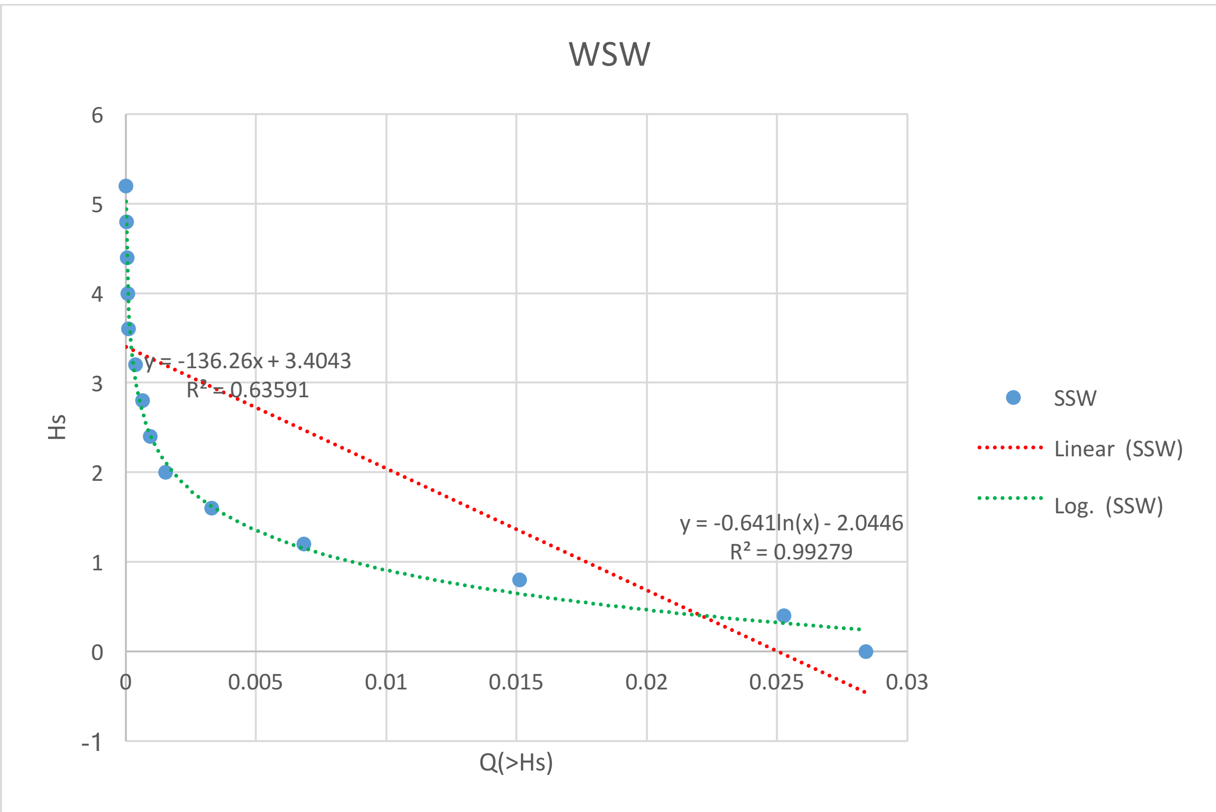


FIGURE 7: NORMAL – NORMAL PAPER WITH H_S AND Q(>H_S)

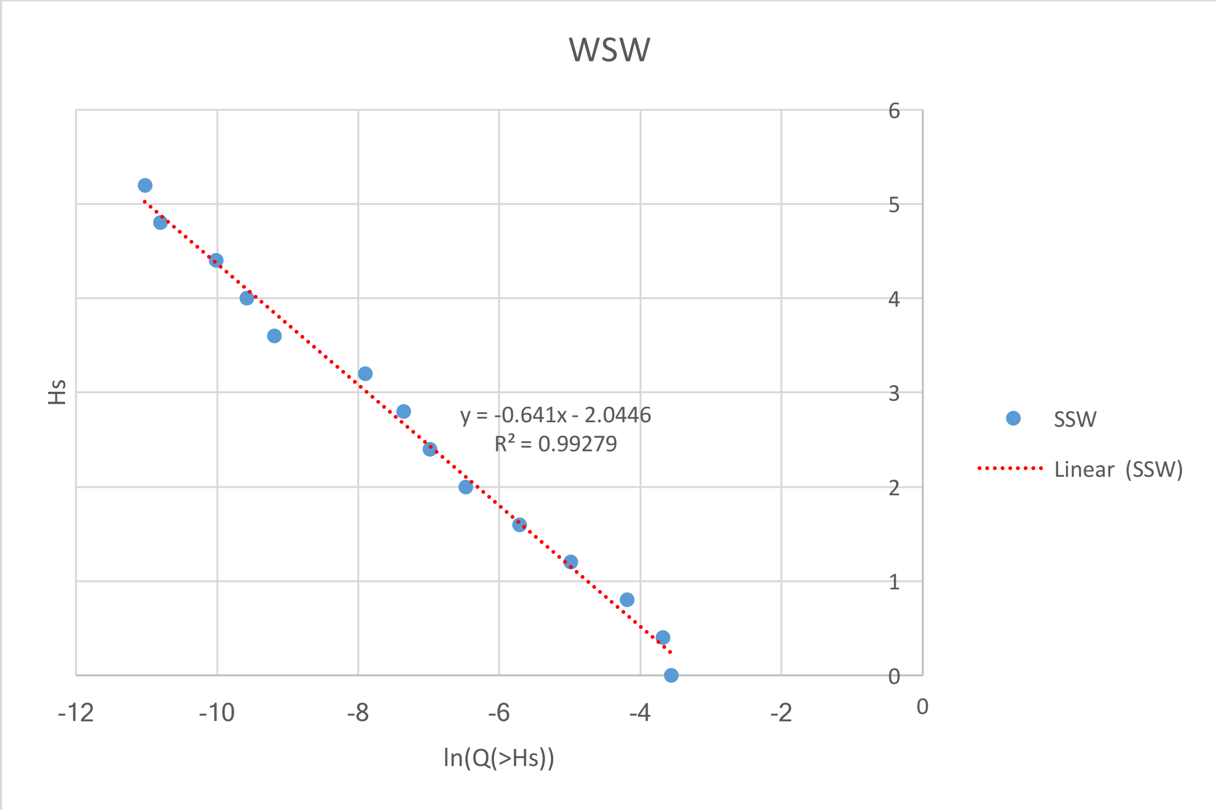


FIGURE 8: NORMAL-NORMAL PAPER WITH H_S VS LN(Q)

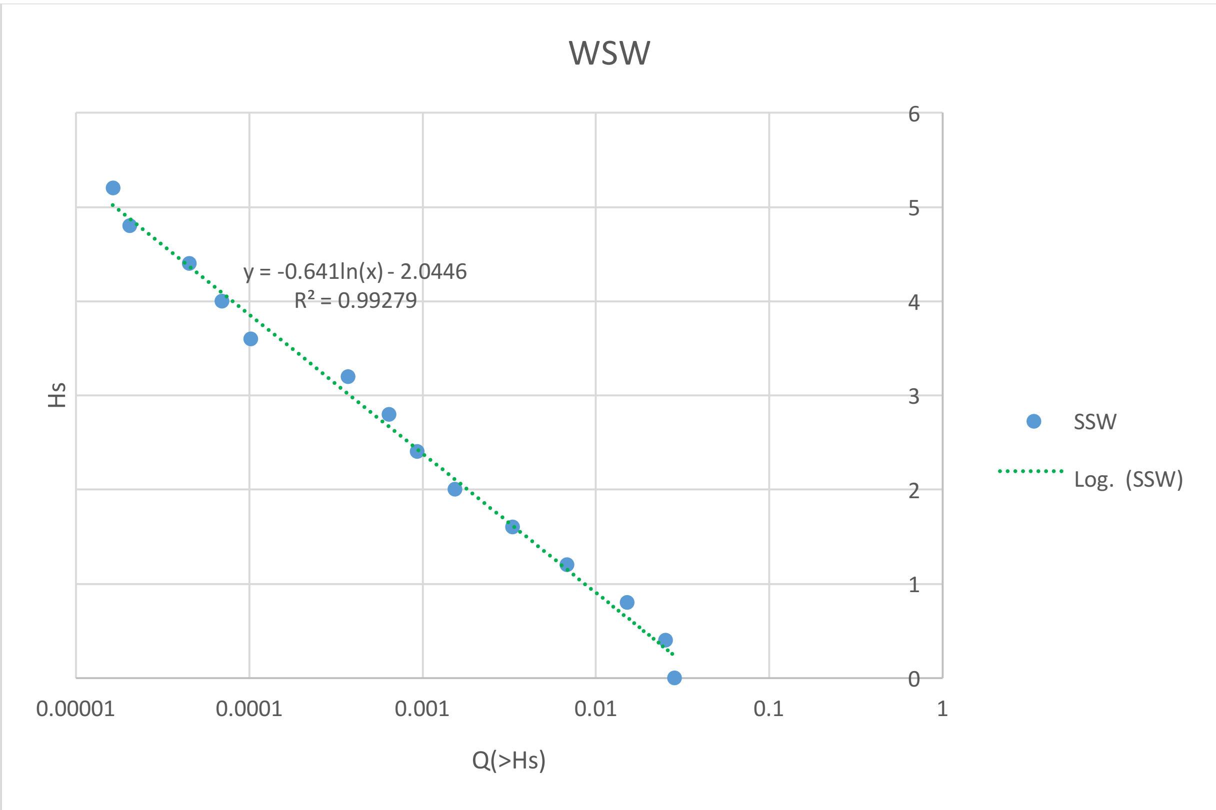
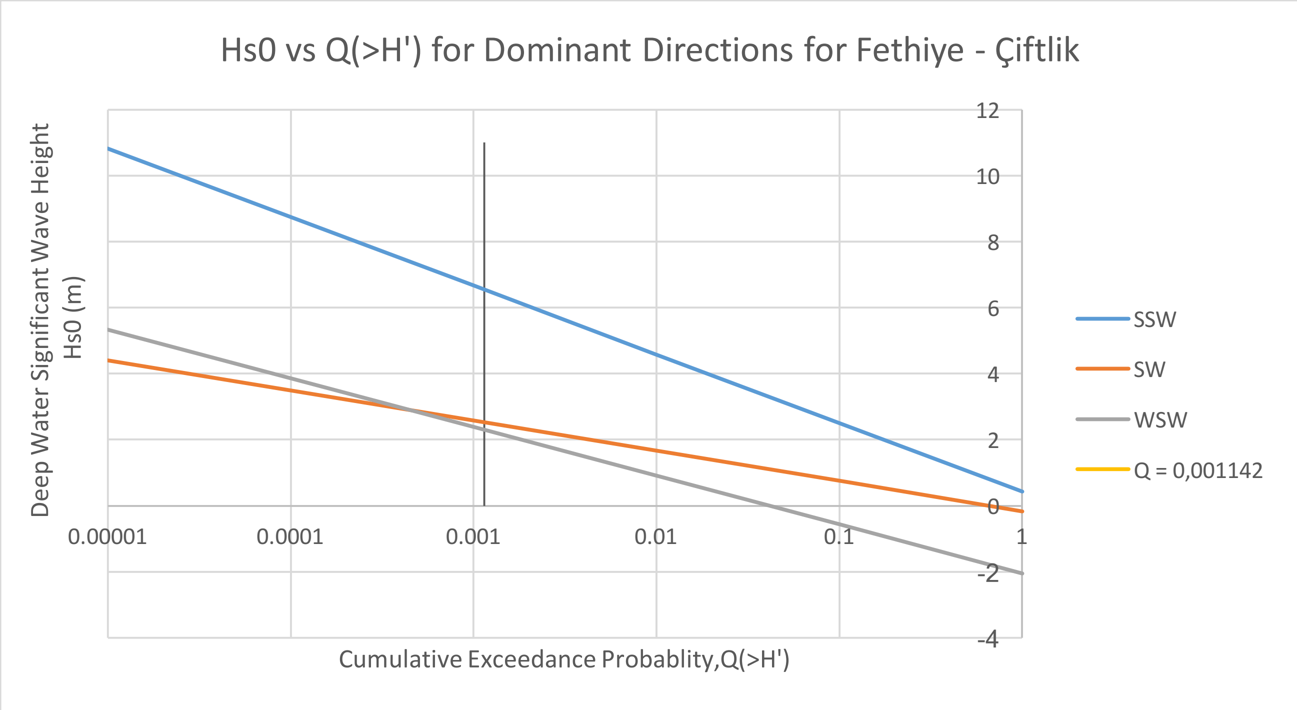


FIGURE 9: LOG – NORMAL PAPER WITH H_S AND Q(>H_S)



After computing long term statistics for Fethiye – Çiftlik site, it is found that the dominant wave direction is SSW with a deep water significant wave height of 5,66 meters and SW direction is second dominant direction in this site.

Deep water wave steepness is given as 0.043 to compute T_s, that is

$$\frac{H_{s0}}{L_0} = 0.043 \rightarrow L_0 = \frac{5{,}66}{0.043} = 131{,}63\ m \rightarrow 1.56T^2 = 131{,}63 \rightarrow T_s = 9{,}19\ seconds$$

$$\frac{H_{s0}}{L_0} = 0.043 \rightarrow L_0 = \frac{2{,}52}{0.043} = 58.6\ m \rightarrow 1.56T^2 = 58.6 \rightarrow T_s = 6.13\ seconds$$

$$\frac{H_{s0}}{L_0} = 0.043 \rightarrow L_0 = \frac{2{,}3}{0.043} = 53.49\ m \rightarrow 1.56T^2 = 53.49 \rightarrow T_s = 5.86\ seconds$$

EXTREME TERM STATISTICS

For computing extreme term statistics according to Gumbel distribution, H_s values are arranged in ascending order (from small to large) and a rank given to them. Then P(<H'), y = -ln(-ln(P(<H_s),Hs^2 and y^2 values are calculated respectively.

m	H_s	P(<H_s)	y=-ln(-lnP(<H_s))	H_s^2	y^2
1	2.41	0.034482759	-1.214109998	5.8081	1.474063
2	2.87	0.068965517	-0.983631068	8.2369	0.96753
3	2.93	0.103448276	-0.819199726	8.5849	0.671088
4	3.08	0.137931034	-0.683602509	9.4864	0.467312
5	3.18	0.172413793	-0.564095975	10.1124	0.318204
6	3.32	0.206896552	-0.454595761	11.0224	0.206657
7	3.55	0.24137931	-0.351632227	12.6025	0.123645
8	3.71	0.275862069	-0.252977491	13.7641	0.063998
9	3.73	0.310344828	-0.157064647	13.9129	0.024669
10	3.81	0.344827586	-0.062703154	14.5161	0.003932
11	3.97	0.379310345	0.031077381	15.7609	0.000966
12	4.03	0.413793103	0.125122073	16.2409	0.015656
13	4.04	0.448275862	0.220214754	16.3216	0.048495
14	4.23	0.482758621	0.317126674	17.8929	0.100569
15	4.54	0.517241379	0.416659084	20.6116	0.173605
16	4.66	0.551724138	0.519686251	21.7156	0.270074
17	4.73	0.586206897	0.627204984	22.3729	0.393386
18	5.05	0.620689655	0.740397979	25.5025	0.548189
19	5.15	0.655172414	0.860721571	26.5225	0.740842
20	5.17	0.689655172	0.990035349	26.7289	0.98017
21	5.24	0.724137931	1.130804774	27.4576	1.278719
22	5.6	0.75862069	1.286436803	31.36	1.65492
23	5.75	0.793103448	1.461873385	33.0625	2.137074
24	5.81	0.827586207	1.664728662	33.7561	2.771322
25	6.5	0.862068966	1.907709152	42.25	3.639354
26	6.54	0.896551724	2.2145807	42.7716	4.904368
27	6.55	0.931034483	2.638631924	42.9025	6.962378
28	6.65	0.965517241	3.349801478	44.2225	11.22117
SUM	126.8		14.95920042	615.4998	42.16235
AVG	4.528571		0.534257158	21.98214	1.505798
			Std.Dev	11.63681	

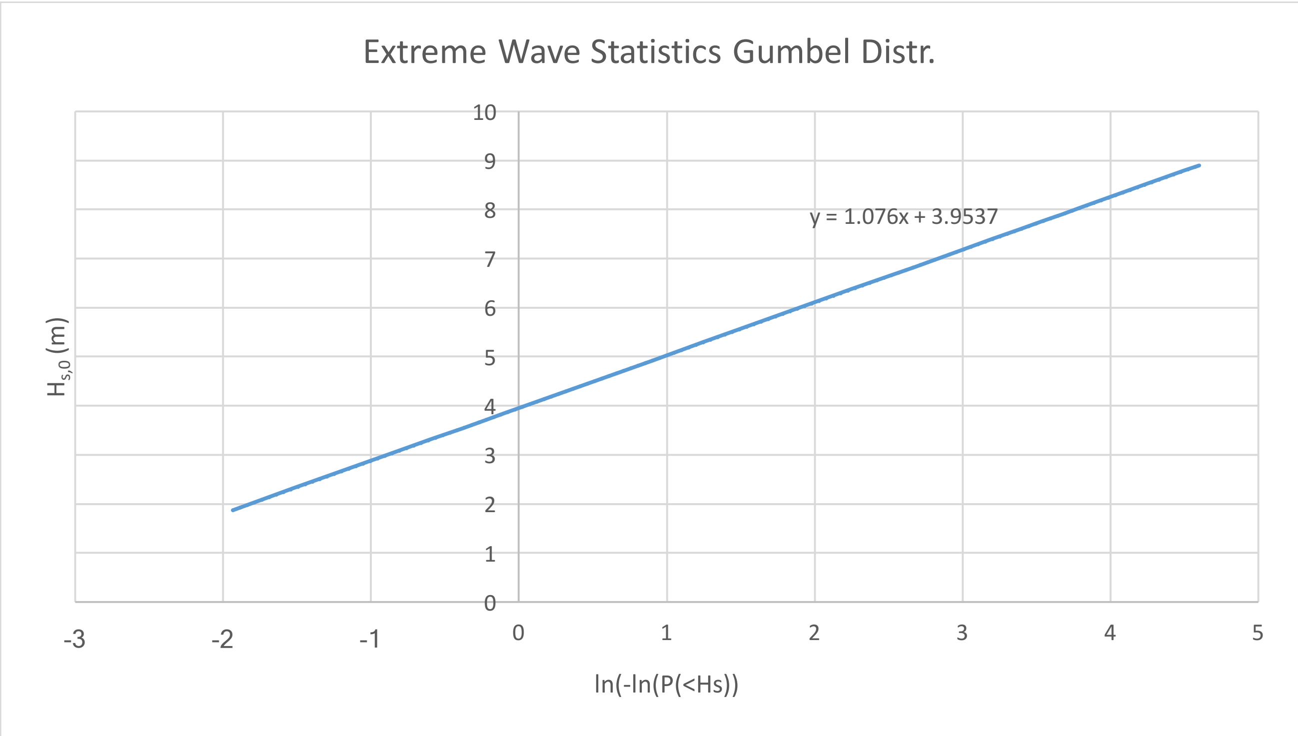
Then the required parameters to fit a best fit curve is calculated;

N	28
$y_{average}$	0.534257
$(y^2)_{average}$	1.505798
$H_{s,average}$	4.528571
$(H_s^2)_{average}$	21.98214

$$A = \frac{\sqrt{(\mathrm{H}_s^2)_{\mathrm{average}} - \left(\mathrm{H}_{\mathrm{s,average}}\right)^2}}{\sqrt{(y^2)_{average} - \left(y_{average}\right)^2}} = \frac{\sqrt{21.98214 - (4.528571)^2}}{\sqrt{1.505798 - (0.534257)^2}} = \frac{1.474185}{1.220367} = 1.207984$$

$$B = \mathrm{H}_{\mathrm{s,average}} - A * y_{average} = 4.528571 - 1.207984 * 0.534257 = 3.883196$$

$$H_s = 1.207984 * y + 3.883196$$



The values for A and B is chosen as 1.076 and 3.9537 from the excel fit respectively.

Since the given data is collected yearly return period is expressed as follows

$$R_p = \frac{1}{1 - P(< H_s)}$$

For return period 50 years

$$R_p = \frac{1}{1 - P(< H_s)} \rightarrow 50 = \frac{1}{1 - P(< H_s)} \rightarrow P(< H_s) = 0.98$$

$$y = -\ln(-\ln P(< H_s)) = 3.901939$$

$$H_s = 1.076 * y + 3.9537 \rightarrow \; H_s = 1.076 * 3.901939 + 3.9537 = 8.15219\, m$$

For return period 100 years

$$R_p = \frac{1}{1 - P(< H_s)} \rightarrow 100 = \frac{1}{1 - P(< H_s)} \rightarrow P(< H_s) = 0.99$$

$$y = -\ln(-\ln P(< H_s)) = 4.600149$$

$$H_s = 1.076 * y + 3.9537 \rightarrow \; H_s = 1.076 * 4.600149 + 3.9537 = 8.90346\, m$$

CONCLUSION

In this project step, long term and extreme term statistical distributions of wind waves are examined. According to the results of those computations, it is found that the dominant wave direction for the selected marina location in Fethiye – Çiftlik is south-south west direction and the secondary direction is south-west direction. Moreover, deep water significant wave height is found as 5.66 meters to use in next project steps for calculation of maximum agitation in harbour. Also, for the design of main breakwater 100 year return period deep water significant wave height is found as approximately 9 meters.

PRELIMINARY DESIGN OF MARINA

The preliminary design of a marina has some tasks creating a specific outline consisting of surveys, consideration of wind, waves, water level and so on. Before this project work, these steps are worked to be done. After these steps, determining layout and the size of the marina has to be determined in preliminary design. Under this scope, the capacity of the marina, dimensions of the yachts and thereby orientation of entrance, piers, mooring at piers and clearance are going to be determined with respect to international standards. After completing the first layout of marina, refraction diagrams are determined according to first trial of breakwater. At the end, wave height which is corrected with shoaling and refraction coefficient is going to be calculated.

FIRST DRAFT OF THE MARINA

The design criteria of the Fethiye Çiftlik marina is that the marina is going to be designed for totally 600 (450 in the sea area, 150 yachts in the land area). 10% of all yachts are longer than 25 m, 30% of all yachts have the lengths in between 15m and 25 meter, 50% of all yachts have the lengths in between 5m and 15 m, the rest are less than 5m. The breakwater will be rubble mound type and berthing structures are going to be piled type.

BOAT DIMENSIONS

Number of the boats with dimensions at the marina can be tabulated as below:

Class	Boat Length(l)	Beam(b) (m)	Draft(d) (m)	# of yachts in sea	# of yachts in land
I	5 ≤ L < 6.5	2.3	1	45	15
II	6.5 ≤ L < 8	2.7	1,5	45	15
III	8 ≤ L < 10	3.2	1.6	45	15
IV	10 ≤ L < 12	3.7	1.7	45	15
V	12 ≤ L < 15	4.3	2	9	15
VI	15 ≤ L < 18	5.1	2.5	30	15
VII	18 ≤ L < 21	5.6	3	48	15
VIII	21 ≤ L < 25	6.2	3.5	44	15
IX	L>25 m	7	4.5	40	15
SB	L< 5 m	2.3	1	45	15
			TOTAL	396	150

During the preliminary design, for standing at the safe side, dimensions are taken at the highest level. For instance, 225 yachts at the marina having length in between 5 m and 15 m, grouped into five classes, boat length is taken as the highest of that class in order to stay at the safe side and beam length taken accordingly.

Since all the yacht lengths are assumed to be largest dimension in their range, only yachts which is larger than 25 meter length is assumed to be 30 meter and related width.

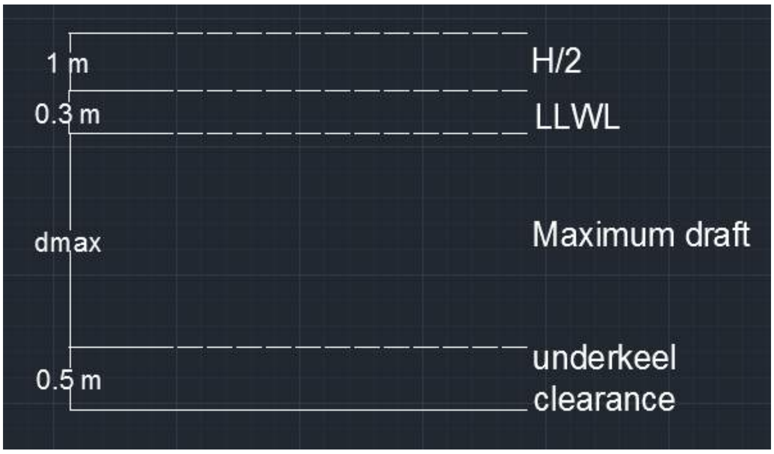
Orientation of Berthed Craft

With the light of the project work 4, the prevailing wind direction from land is taken as SSW direction which is also dominant wave direction. Yachts orientation at the marina is arranged with considering the prevailing wind direction from the land.

Marina Entrance Channel

Depth Of The Entrance

Depth (from LLW) at the entrance is going to be determined from sum of the largest yachts draft, under keel clearance, 30 cm LLWL and H/2 which is assumed 1 meter first.(staying at safe side)



Maximum draft (25 meter yachts) = 4.5 m

Depth of the entrance:

$d' = H/2 + LLWL + d_{max} + clearance$

$d' = 1 + 0.3 + 4.5 + 0.5$

d' = 6.3 meter

Width At The Entrance Channel

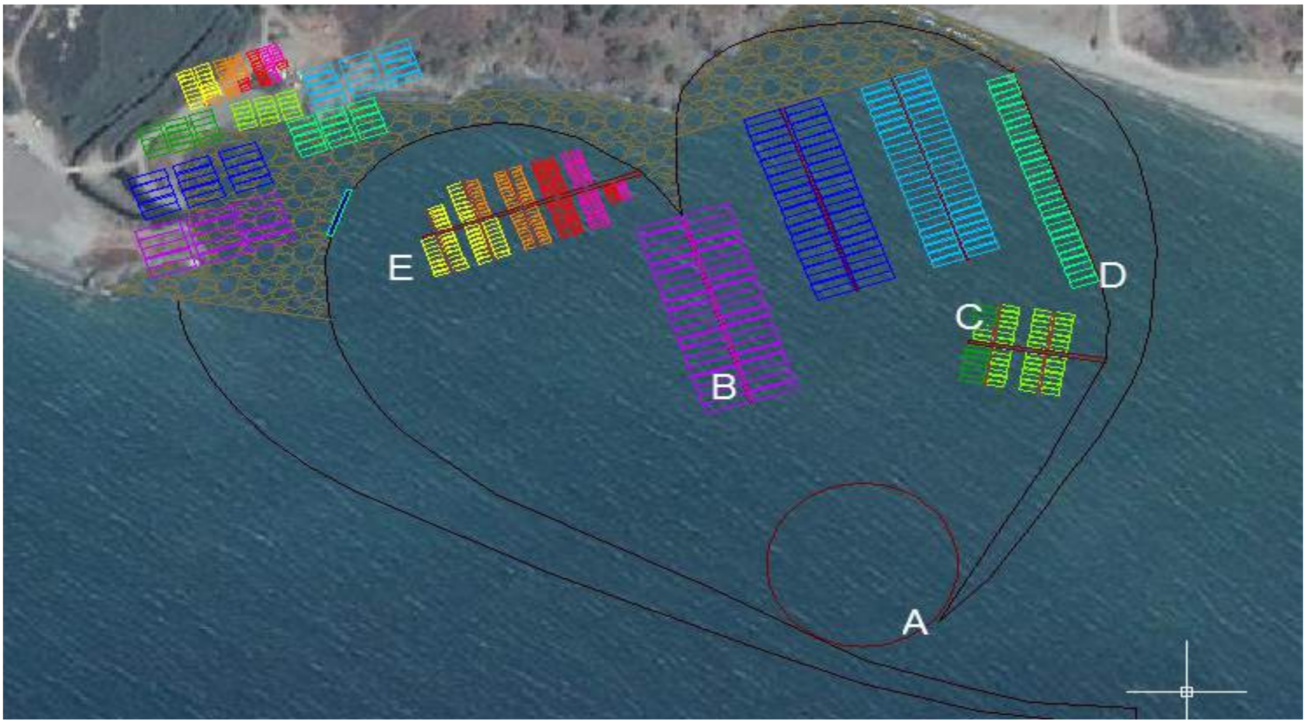
Due to the fact that the investigation of need for secondary breakwater has not done yet, the width at the entrance channel is between the end point of the breakwater and the coast which is about 350 meter.

Maneuverıng Cırcle (Turnıng Poınt)

Minimum maneuvering circle ranges between 50 and 90 meter and also the diameter of the maneuvering is determined as the maximum yachts length times 2 or 2.5. (D = 2~2.5 x L)

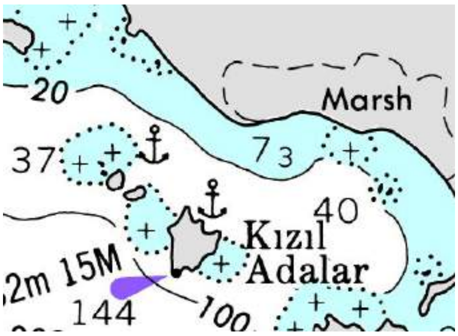
D = 25 x 2.5 = 62.5 meter diameter -> minimum maneuvering circle

LAYOUT OF THE MARINA



The first layout of the marina is designed with respect to international standards. Channel lengths is not more than 150 meter. Distance between cat ways placed two different piers are not more than 1.5 x biggest boat length which is 25 meter. In addition, distance between cat ways at same piers is not more than 3 x biggest boat length. Pier width is typical and it is 3 meter width. Note that boat dimensions in the design is original dimension of the yachts.

Before drawing the breakwater, d/L_0 values are calculated (these steps are placed further part of this report). First of all, from the bathymetry map, 20 meter sea depth is determined and integrate the depth into original map. With the help of scale of the map, distance between 20 meter sea depth and coast can be found and thereby seabed slope can be calculated. After the calculation of seabed slope, d/L_0 values can be found. According to these values breakwater design is going to be performed because of not facing any problems regarding the depth inside and entrance of the marina. The rubble mound breakwater is designed above the $d/L_0 = 0.05$ and that means depth at the entrance is nearly 6.5 meter which is higher than the calculated depth of entrance which is 6.3 meter. However, in order to make depth in the marina more suitable for mega yachts, the depth in the marina is designed as **8 meter.** In order to arrange breakwater, there are some fill areas by fill with dredging of the marina.



For instance: for SSW direction:

$$From\ depth = 20\ meter\ to\ coast$$

$$Distance = 1905.21\ meter\ \rightarrow sea\ bed\ slope = \frac{20}{1905.21} = 0.0105$$

$$\frac{d}{L_0} = 0.1 \rightarrow d = 131.6\ x\ 0.1 = 13.16\ meter \rightarrow distance = \frac{13.16}{0.0105} = 1253\ meter$$

Yachts at the land is arranged with respect to design criteria numbers. Slipway of the yachts is also determined. One another reason for filling the sea is not destructing the forest near the marina and make a space for yachts for land.

WAVE TRANSFORMATIONS

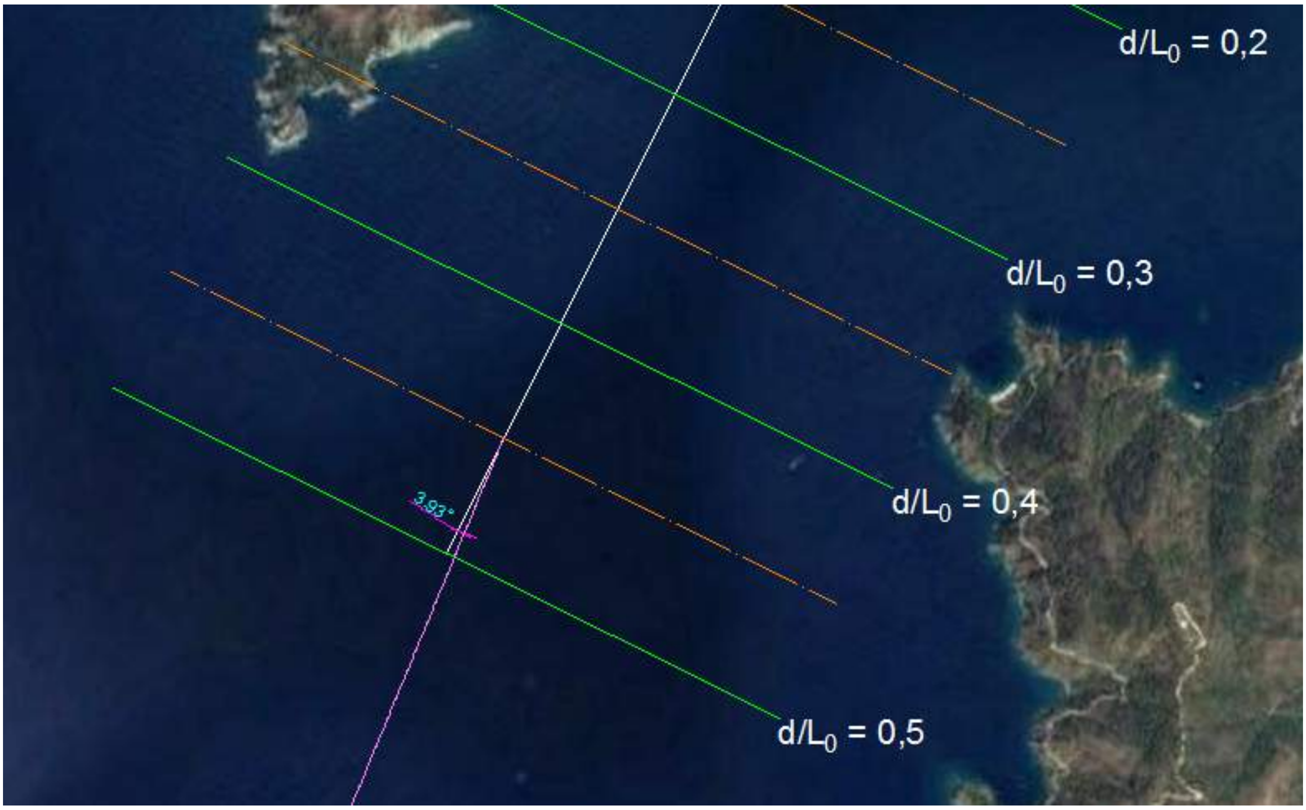
REFRACTION DIAGRAMS

The angles are taken from at the mid depth like $d/L_0 = 0.45$ and two parallel wave direction is used in order to calculate refraction coefficient.

SSW Dırectıon

SSW direction of the wind is nearly perpendicular to the bottom contours; therefore, it is assumed to perpendicular to the bottom contour and calculations are going to be done taking into consideration this situation.

$$K_r = \sqrt{\frac{b_0}{b}} = \sqrt{\frac{cos\alpha_0}{cos\alpha}} \ where\ \alpha_0 = 0^0\ and\ \alpha = 0^0 \ \rightarrow\ K_r = 1$$



SW Dırectıon

At the SW direction, the angel between coming SW wave direction and $d/L_0 = 0.45$ bottom contour orthogonal is 18.57^0. After this point, wave direction changes with respect to Snell's Law.

$$Snell's\ Law\ \rightarrow \frac{sin\alpha_1}{sin\alpha_0} = \frac{L_1}{L_0} = tanh\ k_1 d_1 \rightarrow For\ deep\ water$$

$$Snell's\ Law\ \rightarrow \frac{sin\alpha_1}{sin\alpha_2} = \frac{L_1}{L_2} = \frac{C_1}{C_2} = \frac{tanh\ k_1 d_1}{tanh\ k_2 d_2}$$

$$\rightarrow Between\ any\ two\ depth\ d_1\ and\ \ d_2\ not\ in\ DW.$$

$$\alpha_0 = 18.57^0\ \ \&\ \ \frac{d}{L_0} = \ 0.45\ \ \rightarrow \tanh k_1 d_1 = 0.993 \rightarrow \alpha_1 = 18.44^0$$

$$\frac{d}{L_0} = \ 0.35\ \ \rightarrow \tanh k_2 d_2 = 0.978 \rightarrow\ \alpha_2 = 18.15^0$$

Same principle applied for other depths and results are tabulated below in table.

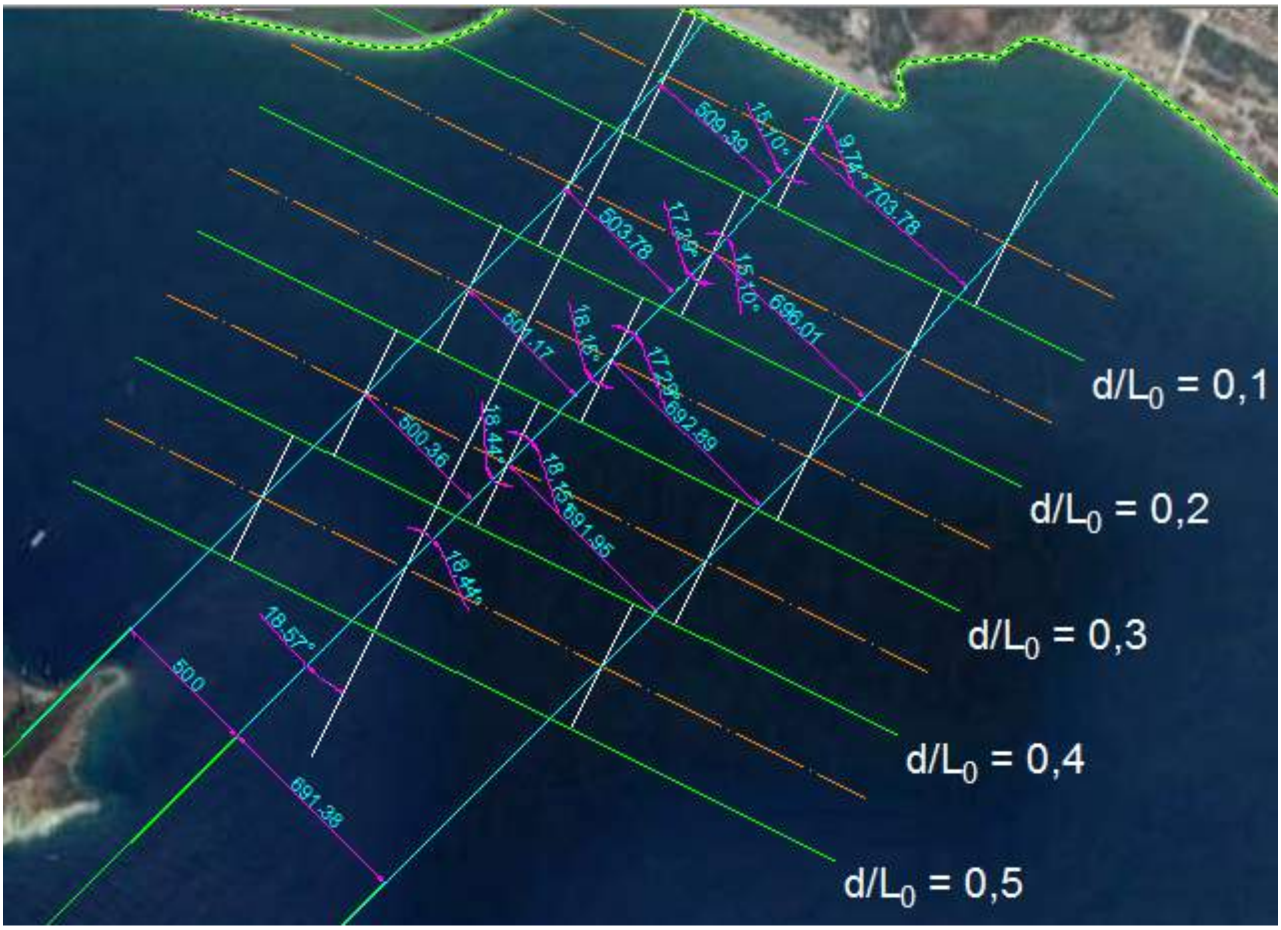
The refraction values are

SW Direction				
DW Approach Angle α0 = 18,57				
d/L_0	$\tanh k_1d_1$	$\tanh k_2d_2$	α_1	$\sin(\alpha_1)$
0.45	0.993	-	18.43531	0.316234
0.35	0.993	0.978	18.14705	0.311457
0.25	0.978	0.933	17.28507	0.297126
0.15	0.933	0.818	15.0999	0.260503
0.05	0.818	0.531	9.73572	0.169104
Kr	0.990875875			

$$K_r = \sqrt{\frac{\cos(18.57)}{\cos(15.1)}} \rightarrow K_r = 0.991$$

Accuracy of the calculated refraction coefficient is checked with using the formulae

$$K_r = \sqrt{\frac{b_0}{b}} = \sqrt{\frac{500 + 691.38}{509.39 + 703.78}} = 0.9909 \cong 0.991$$



WSW Direction

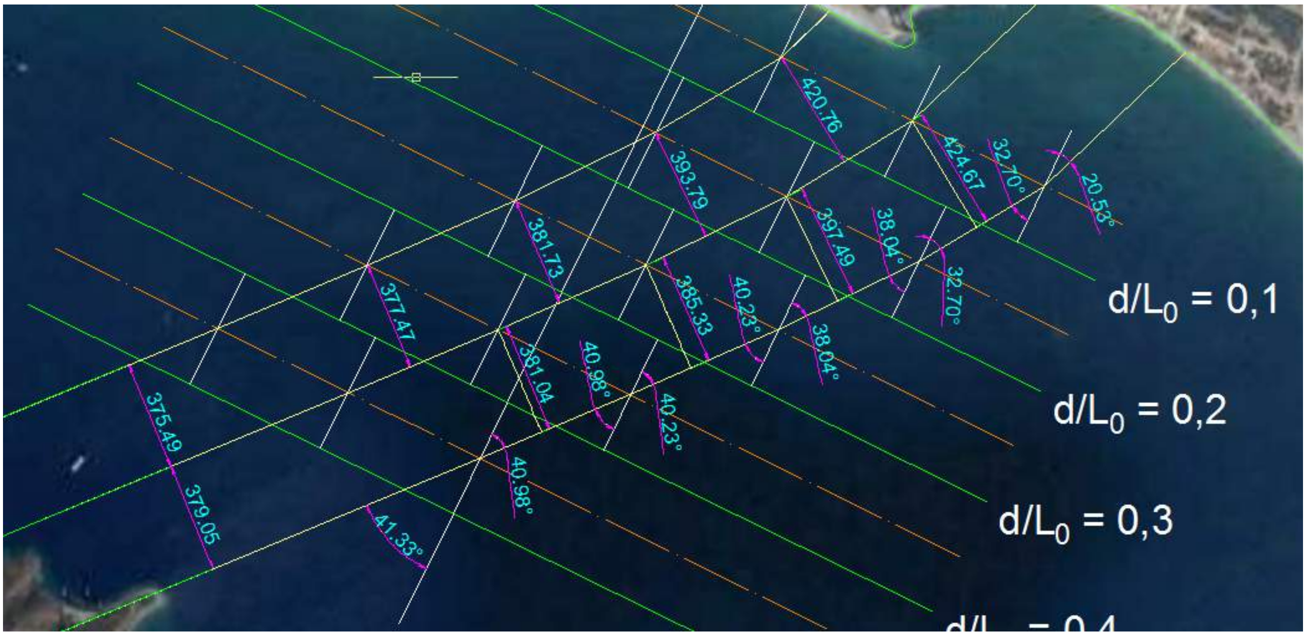
For WSW direction, like SW direction refraction calculations, Snell's Law is used in order to determine the angle of between bottom contour and orthogonal and the table can be established as below:

WSW Direction				
DW Approach Angle α0 = 41.33				
d/L_0	$\tanh k_1d_1$	$\tanh k_2d_2$	α_1	$\sin(\alpha_1)$
0.45	0.993	-	40.97823	0.655772
0.35	0.993	0.978	40.23066	0.645866
0.25	0.978	0.933	38.03542	0.616148
0.15	0.933	0.818	32.69746	0.540203
0.05	0.818	0.531	20.52828	0.35067
Kr		0.944627042		

$$K_r = \sqrt{\frac{\cos(18.57)}{cos\ (15.1)}} \rightarrow K_r = 0.9446$$

Accuracy of the calculated refraction coefficient is checked with using the formulae

$$K_r = \sqrt{\frac{b_0}{b}} = \sqrt{\frac{379.05 + 375.49}{420.76 + 424.67}} = 0.9447$$



Wave Height And Length At the Entrance

SSW Direction

The breakwater is located at $d/L_0 = 0.05$; therefore, from the gravity wave table $K_s = 1.02$

$$L_0 = 131.63\ m \ \rightarrow \ d/L_0 = \ 0.05 \ \rightarrow d = 6.58\ m$$

$$H_{s0} = 5.66\ m \rightarrow H_{(d=6.5m)} = H_{s0}\ x\ \ K_r\ x\ K_s$$

$$Wave\ heigth\ at\ the\ entrance{:}\ \ H_{(d=6.5m)} = 5.66\ x\ 1\ x\ 1.02 = 5.77\ m$$

From GWT Table,

$$d/L_0 = \ 0.05 \rightarrow \ d/L = 0.0942$$

$$Wave\ Length\ at\ the\ entrance{:}\ d = 8\ m \rightarrow L = 85\ m$$

SW Direction

$$L_0 = 58.6\ m \ \rightarrow \ d/L_0 = \ 0.1 \ \rightarrow d = 5.86\ m \ \rightarrow \ K_s = 0.933\ (\ d/L_0\ \ values\ are\ at\ th\ marina\ entrance)$$

$$H_{s0} = 2.52\ m \rightarrow H_{(d=5.86m)} = H_{s0}\ x\ \ K_r\ x\ K_s$$

$$H_{(d=5.86m)} = 2.52\ x\ 0.99\ x\ 0.933 = 2.33\ m$$

From GWT Table,

$$d/L_0 = \ 0.1 \rightarrow \ d/L = 0.142$$

$$Wave\ Length\ at\ the\ entrance{:}\ d = 8\ m \rightarrow L = 56.3\ m$$

WSW Direction

$$L_0 = 53.49\ m \ \rightarrow \ d/L_0 = \ 0.12 \ \rightarrow d = 6.4188\ m \ \rightarrow \ K_s = 0.92\ (\ d/L_0\ \ values\ are\ at\ th\ marina\ entrance)$$

$$H_{s0} = 2.3\ m \rightarrow H_{(d=6.42m)} = H_{s0}\ x\ \ K_r\ x\ K_s$$

$$H_{(d=6.42m)} = 2.3\ x\ 0.94x\ 0.92 = 1.99\ m$$

From GWT Table,

$$d/L_0 = \ 0.12 \rightarrow \ d/L = 0.158$$

$$Wave\ Length\ at\ the\ entrance{:}\ d = 8\ m \rightarrow L = 50.6\ m$$

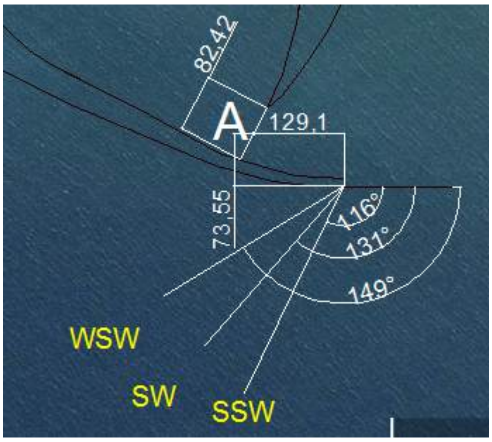
Wave Height and Length at the entrance of the marina									
Direction	**L_0**	**d/L_0 at entrance**	**d**	**d/L**	**H_{s0}**	**K_r**	**K_s**	**H_d**	**L**
SSW	131.63	0.05	8	0.0942	5.66	1	1.02	5.7732	85
SW	58.65	0.11	8	0.141	2.52	0.990876	0.933	2.3297077	56.3
WSW	53.49	0.12	8	0.158	2.3	0.944627	0.92	1.9988308	50.6

DESIGN OF MAIN BREAKWATER

The breakwater of the marina is designed for the safety of the yachts in the marina; in other words, provides the allowable wave height in the marina. Maximum allowable wave height in the marina has to be 30 centimeter. If main breakwater is not enough to provide wave height, then second breakwater should be designed and constructed.

Requirement depth of the marina is calculated 6.3 meter from project work 4. The depth of the marina is 8 meter in order to facilitate calculation.

Wave Height and Length at the entrance of the marina									
Direction	**L_0**	**d/L_0 at entrance**	**d**	**d/L**	**H_{s0}**	**K_r**	**K_s**	**H_d**	**L**
SSW	131.63	0.05	8	0.0942	5.66	1	1.02	5.7732	85
SW	58.65	0.11	8	0.141	2.52	0.990876	0.933	2.3297077	56.3
WSW	53.49	0.12	8	0.158	2.3	0.944627	0.92	1.9988308	50.6



For every wind direction:

$$At\ piont\ A\ (mid\ point\ of\ the\ gate) \rightarrow x = 129\ meter\ \ y = 74\ meter$$

$$The\ location\ of\ point\ A,\ \ A(129m, 74m)\ as\ A(129/85\,, 74/85) = A(1.5, 0.9)$$

Ssw Direction

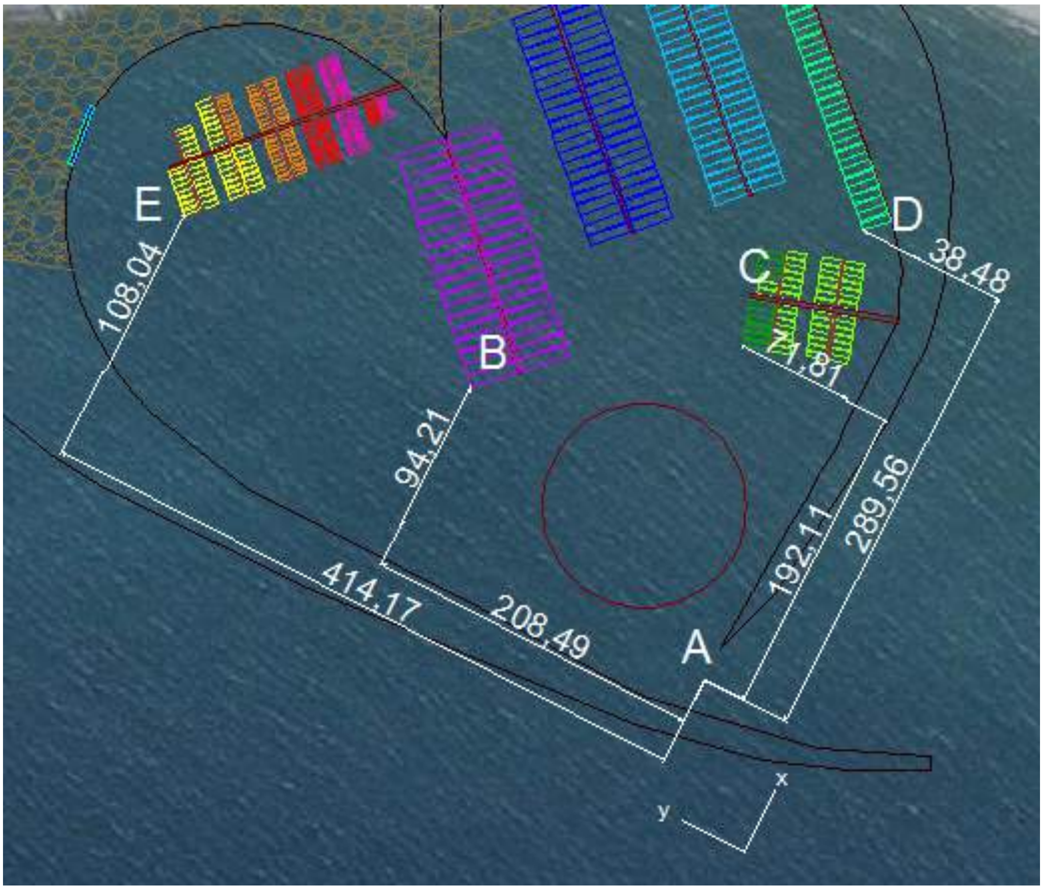
$Waves\ from\ SSW\ direction\ at\ the\ deep\ water\ where\ \beta = 116^0$

$- Diffraction\ Diagram\ \ \beta = 105^0 (assume{:}\ safe\ side)\ with\ A(1.5{,}0.9);\ K_d = 0.15$

$- K_d = \dfrac{H_d}{H_i} \rightarrow H_{d(A)} = 0.15\ x\ 5.77 = 0.86\ meter$

$- Using\ Gap\ Diagram\ B/L = 42.5/85 = 0.5$

$- K_{d(required)} = 0.3/0.86 = 0.35$



There are 4 critical points which distances from the midpoint of the gate is shown below to be checked in order to satisfy K_d requirements:

Point	Distance in x direction (m)	Distance in y direction(m)	x/L	y/L	K_d’
B	94.21	208.49	1.11	2.45	0.29
C	192.11	71.81	2.26	0.84	0.19
D	289.56	38.48	3.41	0.45	0.16
E	108.04	414.17	1.27	4.87	0.24

Since all K_d' values are smaller than the $K_{d(required)}$(=0.35), the wave height in the marina is not problematic. Note that at point D, there is a quay wall exist; however, K_d = 0.16x2=0.32 is also smaller than the $K_{d(required)}$

SW DIRECTION

$Waves\ from\ SW\ direction\ at\ the\ deep\ water\ where\ \beta = 131^0$

$- Diffraction\ Diagram\ \ \beta = 120^0 (assume: safe\ side)\ with\ A(1.5{,}0.9);\ K_d = 0.145$

$- K_d = \frac{H_d}{H_i} \rightarrow H_{d(A)} = 0.145\ x\ 2.33 = 0.34\ meter$

- $Using\ Gap\ Diagram\ B/L = 42.5/56.3 = 0.75$
- $K_{d(required)} = 0.3/0.34 = 0.88$

In order to get K_d' value bigger than $K_{d(required)}$, the points distance is very close to the midpoint of the gate. However, points are obviously enough far away the gate.

WSW DIRECTION

$Waves\ from\ WSW\ direction\ at\ the\ deep\ water\ where\ \beta = 149^0$

$- Diffraction\ Diagram\ \ \beta = 150^0\ with\ A(1.5{,}0.9);\ K_d = 0.13$

$- K_d = \frac{H_d}{H_i} \rightarrow H_{d(A)} = 0.13\ x\ 1.99 = 0.26\ meter$

There is no need for secondary breakwater due to reaching breakwater design wave height in the marina at the gate.

CONCLUSION

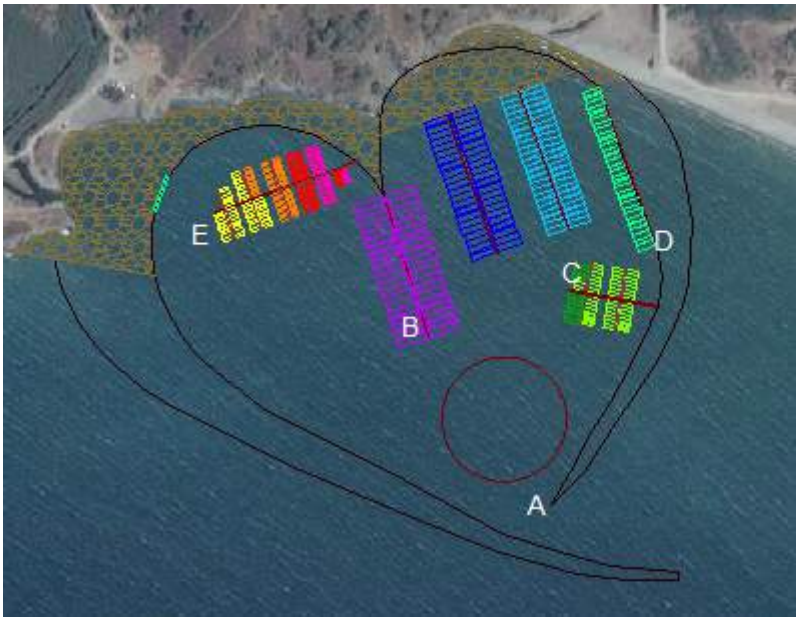
At this project work, for 3 different wave direction, the breakwater alignment is obtained and checked the wave height in the marina. Dominant wave direction is obtained as SSW direction from the wind data analysis, second and third wave direction is SW and WSW respectively. Due the shape of the layout (attraction of the shape), secondary breakwater is designed. However, after the calculation, it already seen that secondary breakwater is also needed.

First thing to do is finding diffracted wave height at the midpoint of the gate connecting main and second breakwater by using diffraction diagrams for single breakwater. After that, required diffraction coefficient is obtained by dividing allowable maximum wave height to diffracted wave height at the gap. There are four critical points to be checked at the marina, and these points are checked with respect to diffraction diagram which is drawn for each ratio of gap width to wave length (B/L=0.5). One of the point is located at the quay wall; therefore K_d value at this point is multiplied with 2 due to the allowable wave height by 0.5. However, this not cause any problem.

For second wave direction required diffraction coefficient is calculated as 0.88. In order to achieve this such a big K_d value, the point located in the marina is very close to the gap; however, there is not any point located at the marina like this situation.

For third wave direction, after the wave is diffracted at the main breakwater, there is no need to design second breakwater due to the wave height in the marine smaller than allowable one. However, design has to be made for dominant wave direction.

Main and secondary breakwaters are designed like below:



DESIGN OF RUBBLEMOUND BREAKWATER

After the length and layout of the main breakwater and second breakwater is determined, the cross section of the breakwater is designed for Hudson and Van Der Meer and Van Gent method. Hudson Approach is classical method to use for designing breakwater section. At this method, in order to obtain more suitable result, it is more suitable to use $H_{1/10}$ instead of $H_{1/10}$ during the calculation of Hudson methodology. The main second approach is to calculate necessary weight of the stone is either Van Der Meer or Van Gent method with respect to its applicability to shallow water. The results from Hudson and Van Der Meer or Van Gent method is compared to each other and stone weight is determined. At the final stage wave run up level is determined and elevation of the breakwater is also calculated after fnding wave run up level.

$$For\ T_R = 100\ years \rightarrow\ H_{\frac{1}{3}} = 8.9\ meters, T_s = 11.52\ sec$$

$$For\ T_R = 100\ years \rightarrow\ H_{\frac{1}{10}} = H_{\frac{1}{3}}\ x\ 1.27 = 11.3\ meters, T_s = 12.98\ sec$$

HUDSON METHOD

When using $H_{1/3}$ during the calculation

From the computations that we computed with Matlab, breaking wave height (H_b) and breaking depth (d_b) are obtained as 8.33 and 10.68 meter respectively.

Depth of breakwater (d_s = 8 meter) < depth of breaking.

$$x_p = (4 - 9.25x0.01)x8.33 = 32.55\ meter$$

$$d_b = d' + x_p \times m \rightarrow d' = 10.68 - 32.55x0.01 = 10.35\ meter$$

$$d_s < d' \rightarrow\ \ BROKEN\ WAVES$$

$$\frac{d_s}{gxT^2} = 0.0061 \rightarrow\ \frac{H_b}{d_s} = 0.85 \rightarrow\ H_b = 6.8\ meter$$

$$W = \frac{\gamma_s\ x\ (H_b)^3 xtan\alpha}{(S_r - 1)^3 xK_{DB}} \rightarrow \frac{2.7\ x\ (6.8)^3 x\ 0.5}{(1.675)^3 x\ 2} = 45\ ton \rightarrow artificial\ stone$$

When using $H_{1/10}$ during the calculation

From the computations that we computed with Matlab, breaking wave height (H_b) and breaking depth (d_b) are obtained as 10.58 and 13.6 respectively.

Depth of breakwater (d_s = 8 meter) < depth of breaking.

$$x_p = (4 - 9.25x0.01)x10.58 = 41.34\ meter$$

$$d_b = d' + x_p \times m \rightarrow d' = 13.6 - 41.34x0.01 = 13.18\ meter$$

$$d_s < d' \rightarrow \ \ BROKEN\ WAVES$$

$$\frac{d_s}{gxT^2} = 0.0061 \rightarrow \frac{H_b}{d_s} = 0.85 \rightarrow \ H_b = 6.8\ meter$$

$$W = \frac{\gamma_s\ x\ (H_b)^3 xtan\alpha}{(S_r - 1)^3 xK_{DB}} \rightarrow \frac{2.7\ x\ (6.8)^3 x\ 0.5}{(1.675)^3 x\ 2} = 45\ ton \rightarrow artificial\ stone$$

VAN DE MEER – VAN GENT APPROACHES

When using $H_{1/3}$ during the calculation

$$T_p = 1.08xT_s = 1.08x11.52 = 12.44$$

$$L_{op} = 1.56x{T_p}^2 = 1.56\ x\ 12.44^2 = 241.48\ meter$$

$$S_{op} = \frac{H_{s,0}}{L_{op}} = \frac{8.9}{241.48} = 0.037$$

$$From\ interpolation\ for\ h/L_{op} = 0.033 \rightarrow \frac{H_s}{h} = 0.545 \rightarrow H_{s,toe} = 4.36\ meter$$

Constraint 1: $h/H_{s,toe}$ = 8/4.36 < 3 ... OK

Constraint 2: $H_{2\%}/H_{s,toe}$ < 1.4 .... OK

$$H_{tr} = (0.35 + 5.8\ x\ tan\theta)\ x\ h = (0.35 + 5.8\ x\ 0.01)\ x\ 8.5 = 3.264$$

$$H_{rms} = \left(0.6725 + 0.2025\left(\frac{H_s}{h}\right)\right) x\ H_s \ = \left(0.6725 + 0.2025\left(\frac{4.36}{8}\right)\right) x4.36 \ = 3.413$$

$$H_{tr} = 3.264 \rightarrow \ H_{rms} = 3.413 \rightarrow \frac{H_{tr}}{H_{rms}} = 0.956\ from\ interpolation \rightarrow \frac{H_{2\%}}{H_{rms}} = 1.598$$

$$\rightarrow H_{2\%} = 5.45\ meter$$

Constraint 3: $H_{s,toe}/H_{s,0}$ = 4.36/8.9 = 0.49< 0.9 .... OK

Therefore, Van Gent methodology is recommended to use.

$$T_{m-1,0} = 0.98\ x\ T_s = 0.98\ x\ 11.52 = 11.29$$

$$\varepsilon_{m-1,0} = \frac{tan\alpha}{\sqrt{\frac{\left(\frac{2\pi}{g}\right) xH_{s,toe}}{{T_{m-1,0}}^2}}} = \frac{0.5}{\sqrt{\frac{\left(\frac{2\pi}{9.81}\right) x4.36}{11.29^2}}} = 3.378$$

$$\varepsilon_{cr} = \left(\frac{C_{pl}}{C_s} x P^{0.31} x \sqrt{tan\alpha}\right)^{\frac{1}{P+0.5}} = \left(\frac{8.4}{1.3} x 0.4^{0.31} x \sqrt{0.5}\right)^{\frac{1}{0.4+0.5}} = 3.94$$

$$\varepsilon_{cr} > \varepsilon_{m-1,0} \rightarrow Plunging\ wave$$

$$\frac{H_{s,toe}}{\Delta D_{50}} = C_{pl}\ x\ P^{0.18}\ \text{x}\ \left(\frac{S}{\sqrt{N}}\right)^{0.2} \text{x} \left(\frac{H_{2\%}}{H_{s,toe}}\right)^{-1} \sqrt{cot\alpha}\ \text{x}\ \varepsilon_{m-1,0}{}^{-0.5}$$

$$D_{50} = 1.437\ meter \rightarrow W = \gamma\ x\ D^3 = 2.7\ x\ 1.437^3 = \mathbf{8\ ton\ (8-10\ ton)}$$

When using $H_{1/10}$ during the calculation

$$T_p = 1.08 x T_s = 1.08 x 12.98 = 14.01$$

$$L_{op} = 1.56 x 14.01^2 = 306.6 meter$$

$$S_{op} = \frac{H_{s,0}}{L_{op}} = \frac{11.3}{306.6} = 0.037$$

$$From\ interpolation\ for\ h/L_{op} = 0.026 \rightarrow \frac{H_s}{h} = 0.582 \rightarrow H_{s,toe} = 4.656\ meter$$

Constraint 1: $h/H_{s,toe} = 8/4.656 < 3$ ... OK

Constraint 2: $H_{2\%}/H_{s,toe} < 1.4$ .... OK

$$H_{tr} = (0.35 + 5.8\ x\ tan\theta)\ x\ h = (0.35 + 5.8\ x\ 0.01)\ x\ 8.5 = 3.264$$

$$H_{rms} = (0.6725 + 0.2025(H_s/h)) x\ H_s = (0.6725 + 0.2025(4.656/8)) x 4.656 = 3.68$$

$$H_{tr} = 3.264 \rightarrow H_{rms} = 3.68 \rightarrow \frac{H_{tr}}{H_{rms}} = 0.887\ from\ interpolation \rightarrow \frac{H_{2\%}}{H_{rms}} = 1.591 \rightarrow H_{2\%} = 5.854\ meter$$

Constraint 3: $H_{s,toe}/H_{s,0} = 4.656/11.3 = 0.412 < 0.9$ .... OK

Therefore, Van Gent methodology is recommended to use.

$$T_{m-1,0} = 0.98\ x\ T_s = 0.98\ x\ 12.98 = 12.72$$

$$\varepsilon_{m-1,0} = \frac{0.5}{\sqrt{\frac{\left(\frac{2\pi}{9.81}\right) x 4.656}{12.72^2}}} = 3.683$$

$$\varepsilon_{cr} = \left(\frac{8.4}{1.3} x 0.4^{0.31} x \sqrt{0.5}\right)^{\frac{1}{0.4+0.5}} = 3.94$$

$$\varepsilon_{cr} > \varepsilon_{m-1,0} \rightarrow Plunging\ wave$$

$$D_{50} = 1.61\ meter \rightarrow W = \gamma\ x\ D^3 = 2.7\ x\ 1.61^3 = \mathbf{11.3\ ton\ (10 - 12\ ton)}$$

Run Up Computations

When using $H_{1/3}$ during the calculation

$$T_{m-1,0} = 0.98\ x\ 11.52 = 11.29$$

$$\varepsilon_{m-1,0} = \frac{tan\alpha}{\sqrt{\frac{\left(\frac{2\pi}{g}\right) x H_{s,toe}}{T_{m-1,0}{}^2}}} = \frac{0.5}{\sqrt{\frac{\left(\frac{2\pi}{9.81}\right) x 4.36}{11.29^2}}} = 3.378$$

$$\gamma_b = 1;\ \gamma_f = 0.64\ from\ linear\ interpolation\ ;\ \gamma_\beta = 0.94$$

$$\frac{R_{2\%}}{H_{s\ toe}} = 1.75\ x\ \gamma_b\ x\ \gamma_f\ x\ \gamma_\beta\ x\ \varepsilon_{m-1,0} \rightarrow R_{2\%} = 15.55\ meter$$

$$Limitng\ value \rightarrow \frac{R_{2\%}}{H_{s\ toe}} = \gamma_f\ x\ \gamma_\beta\ x\ \left(4.3 - \frac{1.6}{\sqrt{\varepsilon_{m-1,0}}}\right) \rightarrow R_{2\%} = 9\ meter$$

Therefore, limiting value governs and $R_{2\%} = 9\ meter$

Conclusion

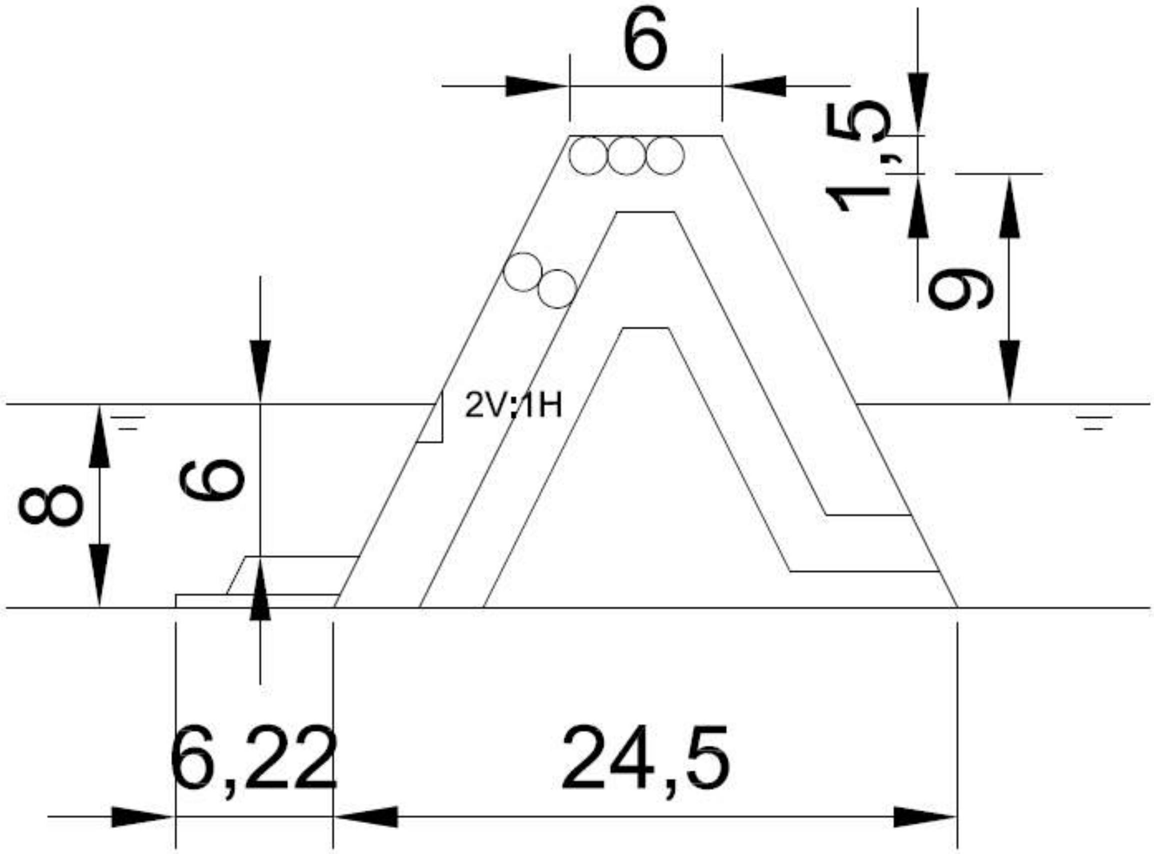
After all the calculation for different approaches, stone weights are found as below:

	Hudson		Van Gent	
Depth	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/3}$**	**$H_{1/10}$**
8 meter	Artificial	Artificial	8-10 ton	10-12 ton
Run up level	9 meter			

Although there is no need to calculate with $H_{1/10}$ for Van Gent method, for comparing results, $H_{1/10}$ is calculated.

The cross section of the break water is like below:

Cross Section of the Rubble Mound Breakwater



*All dimensions in meter

MARINA GENERAL LAYOUT AND SERVICES

A marina should offer not only safe berthing for yachts and boats but also it should contain the facilities and services to attract yacht owners and local people's interest.

LAND FACILITIES

The land facilities that would be constructed in marina is listed below,

- Yacht Club
- Restaurant & Shopping Mall
- SPA & Gym
- Dry Storage
- Beach Bar
- Sport Facilities
- Hotel and Restrooms
- Helipad
- Marina Office and Customs
- Car Park

SERVICES

OFFICE SERVICES

- General Information Desk
- Border gate input-output operations
- Turkish/English daily weather report
- Communication and intercommunication
- Currency exchange

ENVIRONMENTAL CLEAN-UP

- Water circulation system in harbor
- Wastewater collection and decontamination center
- Solid-waste collection stations
- Bilgewater collection and evacuation service
- Waste engine-oil collection station

SAILOR AND DIVER SERVICES

- Diver services
- Tower service
- Immersion tube filling

HEALT SERVICES

- First aid and doctor servies

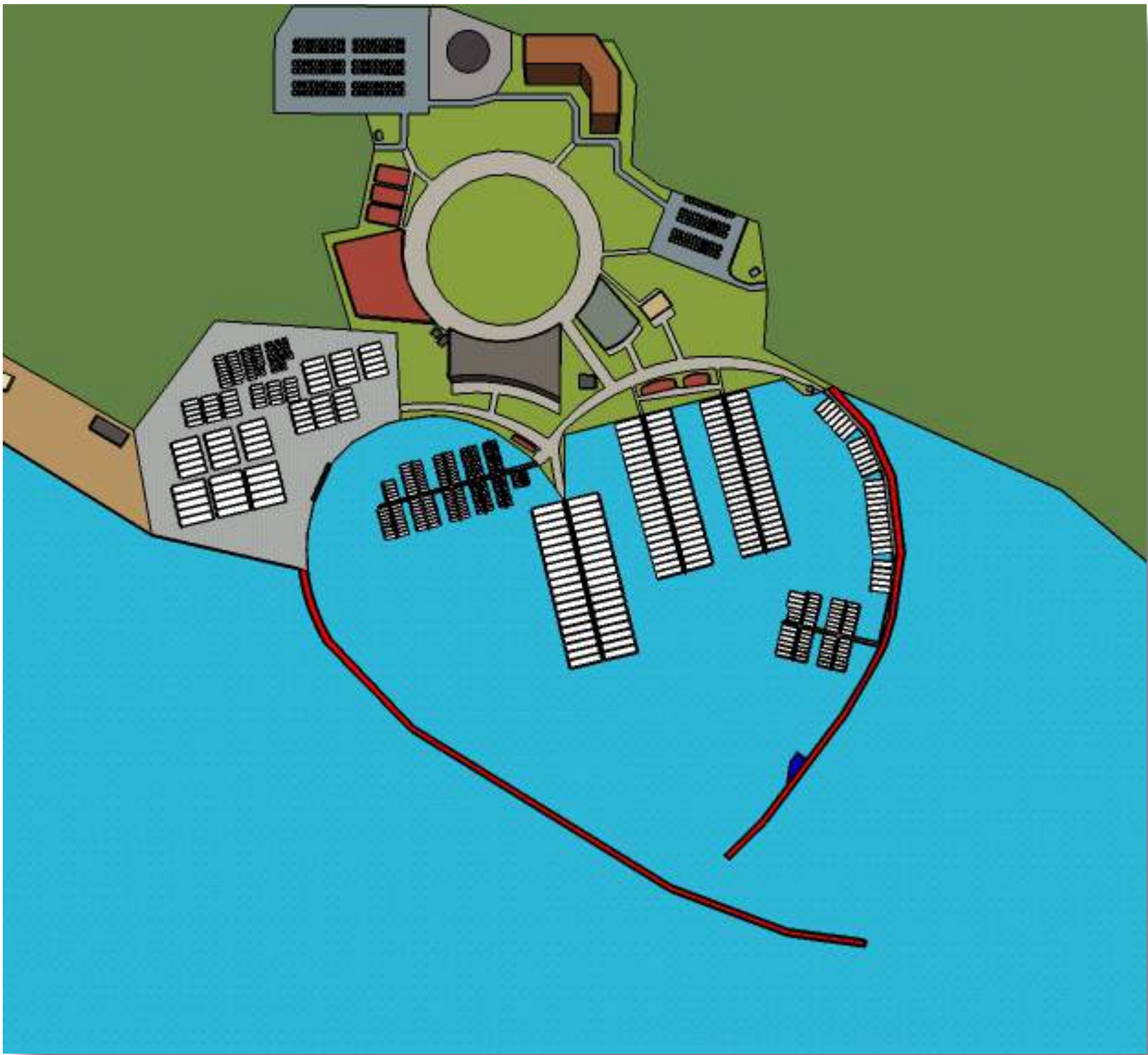
TECHNICAL SERVICES

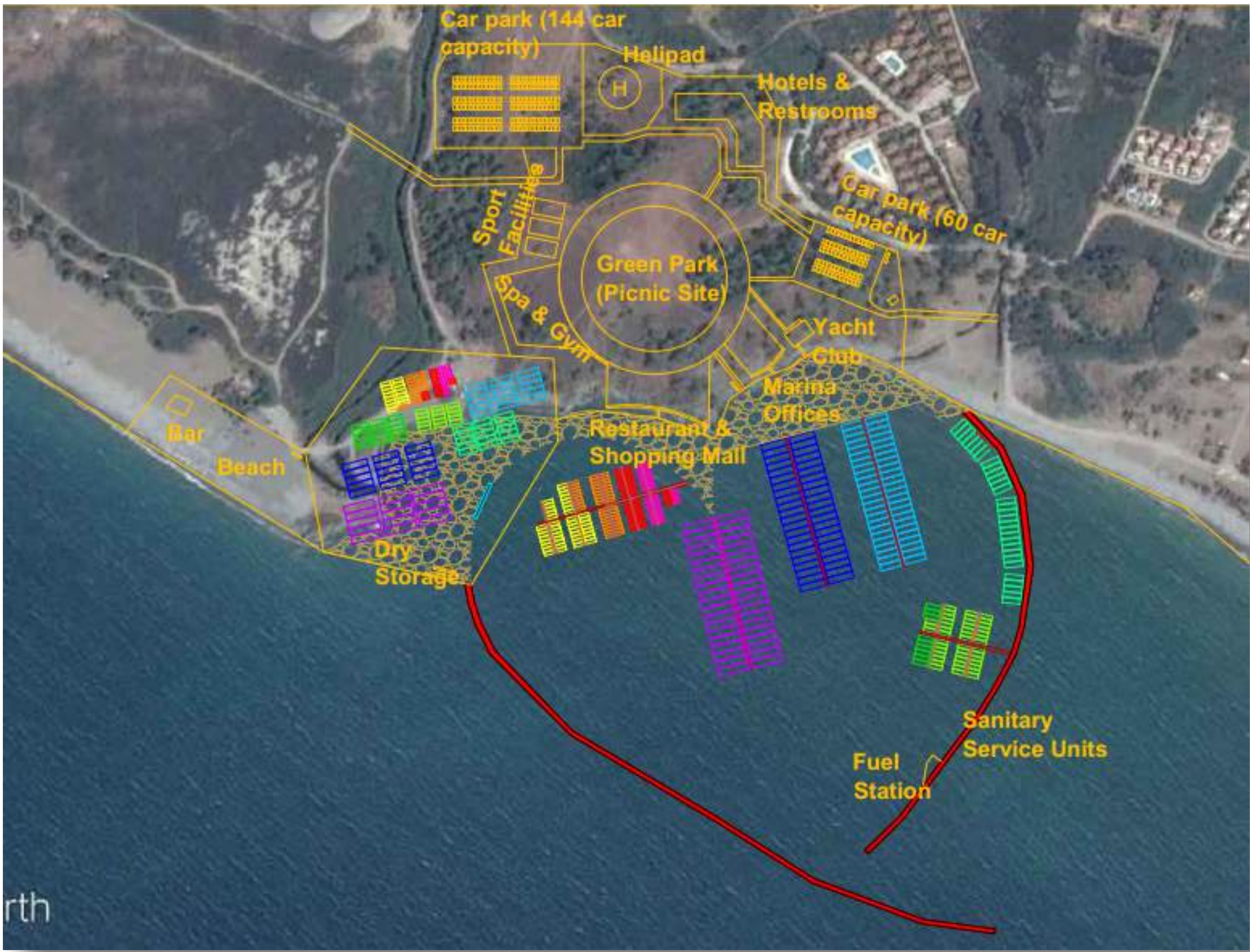
- Maintenance and Repair
- Sliding Crane
- Berth ramp
- Old washing and cleaning
- Wınter maintenance
- Lathe and Metal works
- Sail and brenda maintenance and repair
- Dye
- Wood Furniture applications

GENERAL SERVICES

- 24 hour water and electricity
- Toilets and showers (also for disabled ppls)
- Telephone, Internet and broadcasting
- Deposit and storage services
- Transit fuel supply
- Free-Shop
- Mini-Market
- Drinking water supply

- Fuel Supply
- Fire Fighting
- Yacht Club
- Business Lounge
- Supermarket
- Restaurant
- Crew restaurant and cafeteria
- Laundry and drycleaning
- Rent a Car
- Helipad
- Outdoor parking and parking garage
- Charter and travel agencies
- Banks and ATMs
- Exchange office





ENVIRONMENTAL IMPACT ASSESMENT

All marinas are different and can have different activities going on that change from season to season. As a result, every marina will use different pollution reduction strategies. Marinas are required under federal laws and regulations to take actions to control pollution from normal operations and to prevent accidents.

This part of the report is organized according to the following activities that occur at marinas:

- Hull Maintenance and Cleaning
- Boat Cleaning
- Engine Maintenance
- Bilge Water Handling
- Fueling
- Spill Response
- Boat Sewage and Wastewater Management
- Solid Waste Management

- Shoreside Facilities and Pet Waste Management
- Boat Operations
- Hazardous Materials and Hazardous Waste Management
- Fish Waste Management
- Stormwater Management

HULL MAINTENANCE AND CLEANING

If not properly controlled, hull maintenance activities, including scraping, sanding, pressure washing, and painting, can put toxic pollutants into the marine environment. Where marinas do not provide these services, Do-It-Yourselfers and outside contractors may be performing this work on the marina's property. In all cases, this section provides tools to reduce the potential negative impacts from hull maintenance.

HULL SCRAPING,SANDING AND WASHING

Hull scraping, sanding, and washing releases pollutants that are bound up in hull paint and exposes marine organisms to those pollutants. Employing the following practices will minimize the potential for pollutants associated with hull paint to reach coastal waters.

Designated Maintenance Areas

- Restrict all major vessel repair and maintenance work to designated work areas that are located away from the bulkhead.
- Activities that should be restricted to designated areas include abrasive blasting, pressure washing, hull scraping and sanding, and hull painting.
- Maintenance work such as painting, scraping, and hull cleaning should be done on land, not at marina slips or moorings.
- Underwater cleaning of hulls must be prohibited.

Containment

Maintenance areas should be designed and equipped to minimize the spread of pollutants by:

- Containing all waste and wastewater generated from hull maintenance activities for proper treatment and disposal; and
- Covering the containment areas to prevent rainwater from entering these areas.

To prevent pollutants from seeping into the soil below, all maintenance areas should be located on top of a hard, impermeable surface, such as blacktop. These maintenance areas must be kept clean or covered to prevent rainwater from entering these containment areas and washing away the remnant pollution left over after work, or alternatively, the work area must drain to a storage tank for further recycling, treatment or disposal.

Pressure Washwater Management

Pressure washwater is considered to be a “process” wastewater (or industrial wastewater). Therefore, discharge of pressure washwater to coastal waters, the ground, or a sewer system is illegal without a permit. To meet permit conditions, significant pretreatment of the wastewater prior to discharge would likely be required—regardless of the discharge option chosen.

The significant investments in permitting, training, and operator certification for discharge systems likely make them cost prohibitive. Therefore, recycling systems that treat the wastewater for reuse as washwater without discharge may be a more viable option.

Work Indoors Where practical, conduct vessel maintenance indoors or under temporarily covered areas where the rain cannot cause runoff. Sheet plastic shelters are widely used by many marinas.

Work Away from the Water At a minimum, always move each boat inland to the approved work area before scraping or power washing the hull. Do not allow anyone to perform hull maintenance activities on the launch ramp area or in the lift well.

No In-Water Bottom Cleaning Removal of seaweed and other marine growth on the bottom of boat hulls by divers must be prohibited. This practice is sometimes carried out by owners of sail boats before races in regattas to enhance boat speed. Cleaning of seaweed also removes anti-foulant paint and associated pollutants.

Dustless Vacuum Sanders Dustless sanders use industrial vacuum cleaners to trap dust created in the sanding process before it becomes airborne. As the sander removes paint, dust is drawn into several holes located through the sanding pad. The dust is then sucked into a vacuum container that can be emptied for disposal. Dustless vacuum sanders are one of the best ways to control paint dust before it can become a pollutant.

Tarps and Filter Cloth Use tarps and/or filter cloth to catch scrapings and other debris produced during maintenance work. Tarps and cloth are inexpensive “low-tech”methods to collect debris before it can be washed into coastal waters by stormwater.

Clean Up Designated Areas Clean up the designated work area after scraping and painting. Leaving areas cluttered and messy will cause spills and allow pollutants to be tracked outside the work area.

PAINTING

Because hull paints contain toxic pollutants, they should be used with care.

Designated Maintenance Areas: Restrict mixing of paints, solvents, and reducers, as well as the painting itself, to designated areas that are located on a hard surface and isolated from the weather.

Prohibit Spray Painting on the Water: Sprayed paint can be difficult to control. Paint can be inadvertently sprayed into the water and expose marine life to toxic chemicals.

Clean Up Paint and Supplies: Treat paint spills like oil spills. Clean up immediately with absorbent materials, paper, and/or rags.

Water-Based Paints: Use water-based paints wherever possible. Water-based paints are environmentally-preferable because they use small amounts of VOC solvents.

Inform Do-It-Yourselfers: Provide information to customers who work on their boats at the marina about the potential harm caused by uncontrolled release of paint products.

Train Employees:Train your employees to be on the lookout for hull maintenance activities by Do-It-Yourselfers that may be harmful to the coastal environment.

BOAT CLEANING

Cleaning boats and boat equipment is important for aesthetics and longevity. Somenof the soaps and solvents commonly used in cleaning boats can be toxic to marine life. Consequently, it is important to educate boaters about environmentally–sound cleaning products and practices.

- Cleaning should be restricted to designated maintenance areas
- Promote the use of natural cleaners at your marina. The most natural cleaner you can use is water.
- When a boater needs to use a detergent, suggest phosphatefree soaps that are non-toxic and biodegradable.
- Encourage the use of solvent alternatives by distributing a list of non-hazardous cleaning products.
- When solvents are needed, they should be used in designated maintenance areas only.
- Provide information to encourage your customers who work on their boats at the marina to use environmentally preferable detergents, soaps, and other cleaning products
- Train employees to be on the lookout for cleaning activities by Do-It-Yourselfers that may be harmful to the coastal environment.

ENGINE MAINTENANCE

Engine maintenance is necessary on a regular basis to ensure proper performance of boat engines. Engine maintenance requires using hazardous materials such as oil, solvents, and antifreeze. These substances must be used with care.UTIN

ROUTINE MAINTENANCE

- Set up designated maintenance areas for engine work
- Oil, solvents, anti-freeze, batteries, and other materials generated in engine maintenance is classified as hazardous waste. Extra care should be taken for handling and disposal of these materials.
- Keep engine maintenance areas clean. Regularly sweep or vacuum to keep them free of clutter that can cause spills and collect pollutants.
- Prohibit engine maintenance areas from being cleaned with water from hoses.Water will collect all oil, grease, and lubricants and wash them to drainage structures. Use absorbent materials to clean up liquids.
- Make sure that absorbent materials are always available in the designated maintenance area to immediately soak up any spills. Absorbent materials might include cloths, pads, booms, or granular materials.
- Keep your customers who work on their boats at the marina informed about the proper use of petroleum products and solvents

OIL CHANGES

- **Oil Spill Control:** Use drip pans with absorption pads inside to catch and soak up any spills.Avoid mixing different Hazardous liquids, a practice that can make them unacceptable for recycling and can seriously increase disposal costs.
- **Spill-Proof Oil Changes:** Purchase equipment that will conduct spill proof oil changes. These vacuum systems draw crankcase oil out through the dipstick tube.
- **Recycle Used Oil:** Establish a safe and effective method for collecting, storing, and arranging for transport of used oil for recycling. Used oil collection should be conducted by trained staff only to avoid potential for cross-contamination. The used oil storage area should be safe and secure.

ENGINE CLEANING

Engine cleaning will remove build-up of grease and grime on engine.

- Before using solvents, clean the engine using environmentally-sound alternatives.
- Use non-VOC (Volatile Organic Compounds) solvents where possible to wash engine parts and tools.
- Explore the use of bioremediating systems that use microbes that eat oil and grease.
- Encourage the use of solvent alternatives by distributing a list of non-hazardous cleaning products.

BOAT AND ENGINE WINTERIZING

- **Use Environmentally-Preferable Anti-Freeze**: Traditional antifreeze can kill on contact or when swallowed. Antifreeze is soluble in water and will sink into the water column. If spilled, it can cause immediate harm to plankton and small fish. The "green" colored ethylene glycol antifreeze, commonly used in automobile engines, will kill dogs if they drink it from a spilled puddle. Unfortunately, it tastes good to animals. Switch to less toxic products, such as propylene glycol (orange or pink color), when possible. Propylene glycol anti-freeze is available at most marine supply stores.
- **Fuel Stabilizers:** Add stabilizers to fuel to prevent degradation.
- **Fuel Protection**: Fill fuel tanks to between 80 and 90 percent capacity prior to winter storage to minimize the build-up of flammable fumes and reduce condensation that can lead to corrosion.
- **Drain Water from the Fuel System:** Rather than using anti-freeze, drain as much water from the water system as is possible.
- **Train Employees:** Train employees to be on the lookout for engine maintenance activities by Do-It-Yourselfers that may be harmful to the coastal environment.

BILGE WATER HANDLING

Dumping oily bilge water directly into the water can harm marine life, and is illegal.

- **Prohibit Discharge of Untreated Water by Boaters** Require as part of the environmental contract, or by other appropriate means, that untreated bilge water not be discharged within the marina perimeter.
- **Make Oil Absorbent Pads Available:** Oil absorbent pads absorb oil while repelling water. They are an effective means for collecting oil that leaks into bilge, and thereby preventing the discharge of oily water.
- **Vacuum Systems for Removing Bilge Water:** A vacuum system removes all of the bilge water and pumps it into drums for off-site treatment and disposal.

- **Mandatory Bilge Water Removal:** Make bilge water pumping a requirement for all vessels hauled out at marina
- **Bilge Oil Filters**: Sell and install bilge oil filters. These filters clean bilge water on the boat prior to it being discharged overboard.
- **Portable Oil/Water Separator:** Use a portable oil/water separator to treat oily bilge water and contaminated fuel.
- **Install Oil/Water Separators**: Promote the installation of oil/water separators in bilges.
- **Inform Boaters:** Inform boaters about the negative effects of bilge water discharge.
- **Train Employees:** Train employees to be on the lookout for bilge water discharge by boaters.

FUELING

For many marinas, fueling boats is an essential service to boaters and an important revenue generator. Marinas with fueling services must evaluate all aspects of their operation, including fuel station design, delivery, and dispensation, to ensure that their facility complies with safety, fire, and environmental laws.

- Provide for proper disposal of oil absorption materials and rags
- Regularly inspect the fueling system, and maintain, or replace fuel hoses, pumps, and tanks when necessary.
- Have a dock box or locker on the fuel dock filled with spill absorption pads and containment booms.
- Use oil absorption pads, or fuel collars directly at the gas line to catch splash back and small drips during fueling
- Attach a container to the boat external vent fitting to collect overflow.
- Place a long sausage boom in the water between the dock and the boat to collect any drips and spills
- Place portable gas cans in an oil absorbent-lined drip pan when filling.

SPILL RESPONSE

Spill response preparedness and training is a basic requirement for any fueling facility. A quick response to a spill on the water can prevent major harm to the marine environment. Effective spill control is dependent on having proper spill response equipment readily available and having a well-trained staff.

- **Absorption Booms:** Use a small floating absorption boom tied on the end of a long pole near the fueling station to quickly mop any small spill from the surface of the water.
- **Make Spill Equipment Accessible:** Make spill equipment available to the harbormaster

BOAT SEWAGE AND WASTEWATER MANAGEMENT

Untreated sewage and other boat-generated wastewater dumped into coastal waters can be harmful to humans and marine life. Therefore, it is in your best interest to steer boaters in the right direction with sewage disposal.

- **Providing pumpout services** at marina gives boaters an easy way to do the right thing, and helps keep the waters around your marina clean.
- **Prohibit Sewage Discharge**
- **Shoreside Facilities:** Urge boaters to use the marina's shoreside restroom facilities while at dock or staying overnight.
- **Biodegradable Holding Tank Cleaners:** Promote the use of non-toxic biodegradable cleansers and deodorants for holding tank treatment that do not use formaldehyde.
- **Discharge Prevention Steps:** Encourage all boat owners to prevent discharge while boating in coastal waters by removing their existing Y-valves and seacocks with thru-hulls, or plug hulling the holes; or alternatively, by removing the handle on the Y-valve, or using a wire tie.

GRAY-WATER HANDLING

Graywater is the wastewater from the sink and shower (sewage is called blackwater). Graywater can contain detergents, soap, and food wastes and when released to the environment can reduce oxygen levels in small bays and coves by enriching algae growth and bacterial breakdown of wastes, both of which use up oxygen.

- Educate customers about the impacts of graywater and steps they can take to help reduce graywater impacts.
- Discourage your customers from using dish soaps to clean dishes on board their boats. If soap is necessary for hard to clean jobs, use biodegradable soaps in moderation.
- Sell only low nitrogen detergents in your ship store.
- Providing shoreside dishwashing facilities for boaters and encourage their use.
- Encourage customers to use the showers and restrooms provided by the marina when at the docks.

SOLID WASTE MANAGEMENT

The type of solid waste found in marinas includes trash from boat maintenance and repair, the marina office and store, and the boats themselves.

- **Boat maintenance and repair examples**: Shipping boxes, board and metal scraps, cleaning rags, paper, old engine parts, fiberglass chips, sawdust, construction waste, sand blasting waste, floor sweepings, sanding dust etc.

- **Marina office and store examples**: Waste paper, boxes, shipping materials, floor sweepings, cups, used office supplies, bottles, cans, garbage, etc.
- **Boat examples:** Drink containers, food scraps, garbage, fish cleaning waste, old fishing line, dirty cleaning rags, cigarette butts, papers, plastic bags, utensils and plates, etc.

BEST MANAGAEMENT PRACTICES

Solid Waste Disposal

- **Recycling Strategies:** Developing a waste and recycling strategy based on the characteristics of the marina that considers factors such as the number of boats, types of boats and activities, and length of docks.
- **Used Battery Storage and Disposal:** Used batteries must be stored in a single layer on pallets or shelving with an impermeable or sealed base until they can be recycled or disposed of at an appropriate location off-site.
- **Trash Container Placement:** Placing covered trash receptacles in lighted areas and in locations that are convenient for marina customers. It is avoided placing trash containers on docks where trash can be inadvertently blown into the water.
- **Locate Dumpster Away from the Water:** Placing the dumpster as far away from the water as is feasible yet still convenient for use.
- **Litter Bag Distribution:** Distributing free litter bags to customers to encourage them to bring back all trash.

Staff Responsibilities

- **Trash Clean Up:** Making picking up stray trash at the marina a daily practice required of all staff.
- **Pool Skimmers:** Use a pool skimmer or some other net for collecting floating trash around the docks.
- **Trash Awareness:** Posting signs to remind customers where they can dispose of different trash.

Recycling

- **Mark Recycling Containers:** Clearly mark each recycling receptacle to prevent mixing of recyclable materials. Containers should be provided for plastics, paper, bottles, cans, and other recyclables. Establish a marked place for used battery recycling.
- **Recycling Signs:** Post signs to direct customers to the recycling area and to inform them how to separate their waste.

SHORESIDE FACILITIES AND PET WASTE MANAGEMENT

Bacteria from shoreside restrooms and uncontrolled pet waste can contaminate waters around the marina. Shoreside sanitary facilities should be functioning properly to protect public health and the environment. Pets should be led to designated walking areas and their owners should take responsibility for properly disposing of pet waste.

BEST MANAGAEMENT PRACTICES

Shoreside Sanitary Facilities Management

- **Clean Restrooms:** Providing clean, safe, dry, well-lit, and ventilated restrooms for your customers 24 hours a day.
- **Septic System Maintenance**: Ensuring proper functioning and management of shore side facilities including septic systems and sewer connections and pumping septic tank on a regular basis.
- **Dishwashing/Laundry Facilities**: Providing an area near the restrooms where boaters can clean their dishes. Also, consider providing laundry facilities for your customers.

Pet Waste Management

- **Dog Walking Areas:** Providing a specific dog walk area at the marina with signs to direct customers.
- **Pet** Waste Disposal: Requiring marina customers to immediately clean up all pet feces. It is also considered installing mini septic systems for pet waste.
- **Pet Regulations:** Include relevant pet rules and regulations in patron contracts and signage.

FISH WASTE MANAGEMENT

Sport fishing is one of the most popular uses of boats. However, fish cleaning waste produced by recreational fishermen can become a major nuisance if not properly handled.

BEST MANAGAEMENT PRACTICES

- **Offshore Cleaning and Disposal:** Encourage fishermen to clean fish off-shore and discard fish waste at sea.
- **Fish Cleaning Area and Rules:** The best way to prevent a problem is by developing and clearly marking a fish cleaning area and posting rules for disposal of fish waste on the marina property. This will prevent fishermen from cleaning and disposing of fish at improper locations.
- **Fish Cleaning Staff:** Providing a staff person who can clean fish for fishermen for a per pound service charge.

- **Covered Containers:** Treat fish waste like any other solid waste that requires covered containers.
- **Fish Cleaning Provisions in Customer Contracts:** Include requirements for cleaning fish in the customer's environmental contract.
- **Fish Composting:** Composting fish waste where appropriate by mixing it with peat moss or wood chips to make garden mulch. This quickly produces an excellent compost for use in the marina gardens without any odor problem.

BOAT OPERATIONS

Boats allow people to explore the backwaters of marshes, visit stretches of barrier beach miles from the nearest road, and reach rocky islands offshore. Improper use of boats in these areas can cause harm to these healthy habitats.

To keep your marina clean and reduce impacts to coastal waters, it is important to provide boaters with the right tools and information so they can do their part. To help boaters understand potential impacts of their boating behavior on marine habitats, distribute the boater fact sheet on this subject from the back inside pocket of this guide.

BEST MANAGAEMENT PRACTICES

- **Observe No Wake Zones:** In No Wake Zones, boat speed must be decreased to the point where the boat does not produce a wake (or waves). These zones are located in boating channels where there is a significant amount of boat traffic, in areas where boats are docked and moored, and in salt marsh areas where wakes cause erosion which can lead to boat channel filling.
- **Promote Safe and Responsible Use of Boats:** Encouraging all boat operators (including personal watercraft riders) at the marina to complete an approved boating safety course of training.
- **Avoid Boating in Shallow Waters:** Inform boaters about the environmental damage caused by boating in shallow waters, particularly to eelgrass. As described above, eelgrass is particularly at risk for damage by boat propellers because it grows in shallow waters. Local marine resource departments might consider posting signs informing boaters about sensitive areas.
- **Do Not Speed Near Salt Marsh:** Because salt marsh naturally forms in low energy environments away from wave action, it is particularly susceptible to boat waves. Regular boat waves will lead to erosion and destroy salt marsh.

STORMWATER MANAGEMENT

Storm water runoff is the water from rain and melting snow that flows across the land to local water bodies. As this water runs off the land, it has the potential to pick up pesticides, silt, oil, and other contaminants along the way.

Reducing storm water pollution can include either:

• Practices that prevent pollution from coming into contact with rain water, or

• Practices that clean polluted storm water before it enters coastal waters.

Best Managaement Practices

Proper Operations and Maintanance

- **Street Sweeping:** Frequently sweeping streets, parking areas, boat maintenance areas, and other paved surfaces, including walkways, to maintain a clean marina. This marina also employ small mobile vacuum sweepers to daily drive around their paved areas. However, regular sweeping with a dust pan and broom, particularly near catch basins, can be just as effective.
- **"Don't Dump" Stenciling:** Stencil "Don't Dump" signs next to catch basins. This will help inform the general public that catch basins are directly connected to coastal waters.

Facility Improvements

- **Reduce Pavement Area:** Removing pavement as soon as possible and at the marina and switching the pavement to grass or gravel.
- **Move Parking Areas: R**elocate parking areas away from the water. It may be opportunities to move parking off-site, which will allow you to maximize facility space and improve its visibility.

Improving the Site Drainage System

- **Oil/Grit Separators:** These devices are placed in the drain line to remove oil and sediment. Water passes through several chambers, trapping oils that float on top of the water and sediments that fall out.
- **Leaching Basins:** These basins generally replace or modify existing catch basins by adding an area of crushed stone to help filter storm water.
- **Filters in Catch Basins:** Filter screens can be placed under catch basin grates to collect large sediment particles.
- **Sand Filters:** Sand filters collect runoff and filter it through a sand medium, which is effective in removing sediments and oils.

HAZARDAOUS MATERIALS AND HAZARDOUS WASTE MANAGEMENT

Hazardous materials — gasoline, oil, paints, and solvents — are used in a variety of marina activities and services, and must be managed carefully. This section discusses the requirements for hazardous materials management and hazardous waste disposal.

Best Managaement Practices

Planning, Training and Spill Coordination

- **Provide Employee Training:** Training employees on proper handling, storage, transfer, and disposal practices for hazardous materials and hazardous waste.
- **Coordinate with Town Safety Departments:** Ensuring that local response officials, particularly the fire department, are familiar with the location and character of hazardous materials stored on site.
- **Establish a Facility Hazardous Waste Plan:** Developing a plan that includes information about hazardous materials used and waste generated at the marina. This plan should include the following information: type of waste accepted; details about the storage area and design requirements.
- **Use Signs:** Posting signs that locate hazardous waste disposal, recycling, and reuse areas.

Storage and Disposal

- **Proper Hazardous Materials and Waste Storage:** Hazardous materials and waste should be stored in closed containers inside a building and on impervious surfaces (such as asphalt or concrete), as far from the water as possible.
- **Container Labeling:** All containers must be labeled with information that includes what is inside the container and when the waste was generated.
- **Regularly Inspect and Maintain Storage Areas:** Regularly inspecting storage areas to check for leaky containers.
- **Secure the Hazardous Waste Storage Area:** Ensuring that hazardous waste storage areas are secure and preventing access to these areas by untrained employees or customers.
- **Minimize On-Site Hazardous Material and Waste Storage:** Keeping the total volume of hazardous material and waste stored to a minimum.

Reuse and Recycling

- **Properly Collect Wastes:** Collecting the following waste products from customers for reuse and recycling: engine oil, antifreeze, paints and solvents, varnishes, pesticides and transmission fluid.

- **Maintain a Product Exchange Area:** Establishing a hazardous material exchange area where customers can drop-off unused paint, varnish, oil, and other materials for other customers to use.
- **Require Recycling in Contracts:** Making recycling a requirement under customer and outside contractor contracts.
- **Used Oil Burner:** At the marina, there is a waste oil burner as a winter heating source.

SOCIO ECONOMIC ASPECTS

EXISTING SOCIO-ECONOMIC ENVIRONMENT

- The population in the Fethiye has grown rapidly in the past five years, almost increased %30. This is likely due to young adults migrating to the region in search of job opportunities and coastal lifestyle.
- Fethiye is a culturally diverse area, recording a high percentage of English born persons
- Average household incomes are lower in Fethiye although have grown at a faster rate in the past five years
- Fethiye economy is highly reliant on not only agriculture but also the accommodation, cafés and restaurants sector largely attributable to the Fethiye's position as a key leisure tourism destination
- Fethiye has a relatively high proportion of persons employed in the occupations of labourers and community and personal service workers,
- The immediate area and surrounding service center of the Fellowship Marina Development has considerable social, community and recreational infrastructure capable of servicing the majority of the local population's needs.

LABOUR FORCE IMPACTS

The proposed Fellowship Marina Development is expected to impact on the labour market of the immediate Fethiye-Çiftlik area and the surrounding service center during both the construction and operational phases, in terms of labour and skill requirements.

POPULATION IMPACTS

Population impacts from the Fellowship Marina Development can result from the attraction of labour, visitors and residents that would not otherwise come to the region, and can have significant flow on impacts on demand for social infrastructure and services.

DEMOGRAPHIC, SOCIAL AND CULTURAL IMPACTS

The size and scope of the proposed development has the potential to generate impacts on the existing demographics, lifestyle and values of the local community, access to requisite social, community and recreational facilities and services, accessibility of property, and cultural heritage. These impacts can be related to physical changes in the environment from the development itself as well as increases in population.

TRANSPORT ACCESSIBILITY AND SAFETY IMPACTS

The Fellowship Marina Development has the potential to impact on the accessibility and safety of transport networks in the local area.

IMPLICATIONS FOR FUTURE DEVELOPMENTS IN THE LOCAL AREA

The development will provide opportunities for existing business growth and expansion due to enhanced local access to the marina and associated facilities, particularly for businesses in related upstream and downstream industries.

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