increase in concentration is observed at fewer monitoring point locations when considering sulphur dioxide rather than nitrogen dioxide.

In general, there will be improvements in the air quality for many of the monitoring point locations that currently exceed K-EPA / MOO air quality criteria.

9.4.6.3 SRU Upset Case Modelling

The following two SRU upset conditions have been modelled (note that typical SRU emissions are included with the "Normal Emission" Scenario):

Upset 1: SCOT sections are bypassed. This scenario is not intended for continuous sustained operation, and it results in high SO_2 emissions. Note that the SCOT Unit is designed for 99%+ reliability.

Upset 2: SCOT sections are bypassed; incinerator is not in operation, and is cold with no combustion air. As for the other SRU upset condition, this scenario is not intended for continuous sustained operation, and it results in high H_2S and SO_2 emissions. Note that the failure rate for a SRU/TGTU incinerator is low.

The emission data for the SRU upset scenarios are provided in Table 9.13.

Normal Case (see Section 9.4.3 and Table 9.8) emissions have been modelled together with each of the two upset conditions

Results from the modelling (short term concentrations only), shown below, are compared only against applicable occupational exposure standards for relevant pollutants, as upset conditions are short term emergency events. It is also noted that to make a meaningful comparison with typical occupational exposure limits, which are provided for 15-minute exposure and 8 hour exposure period (see Table 9.16), the maximum predicted short term, 100%ile, 1-hour concentration (for the relevant pollutant) anywhere within the CFP boundary and the adjacent area was converted to the equivalent 15-minute and 8 hour average concentration using one of the factors provided (1.07 and 0.95 respectively for this case) in the *Workbook of Atmospheric Dispersion Estimates, D. Bruce Turner, 2nd Edition, 1994.* The 99.7%ile results are also provided for information.

<u>SRU Upset 1</u>

The ground level maximum concentrations for MAA and MAB predicted anywhere for SO_2 are summarised in the table below. Note that the decommissioned results have not been taken into account, as they are negligible compared against these emergency emissions.

Table 9.23: Maximum Ground Level Concentrations for SO_2 Anywhere

SO_2(µg/m³)	100 %ile			99.7%ile		
	1 hr	15 min avg	8 hr avg	1 hr	15 min avg	8 hr avg
MAA	1250	1338	1187	726	777	690
MAB	2230	2386	2119	1330	1423	1264

The following table summarises the results as a comparison to the occupational exposure limits, as shown in Table 9.16.

Table 9.24: Maximum Ground Level Concentrations for SO_2 as Percentage of the Criteria

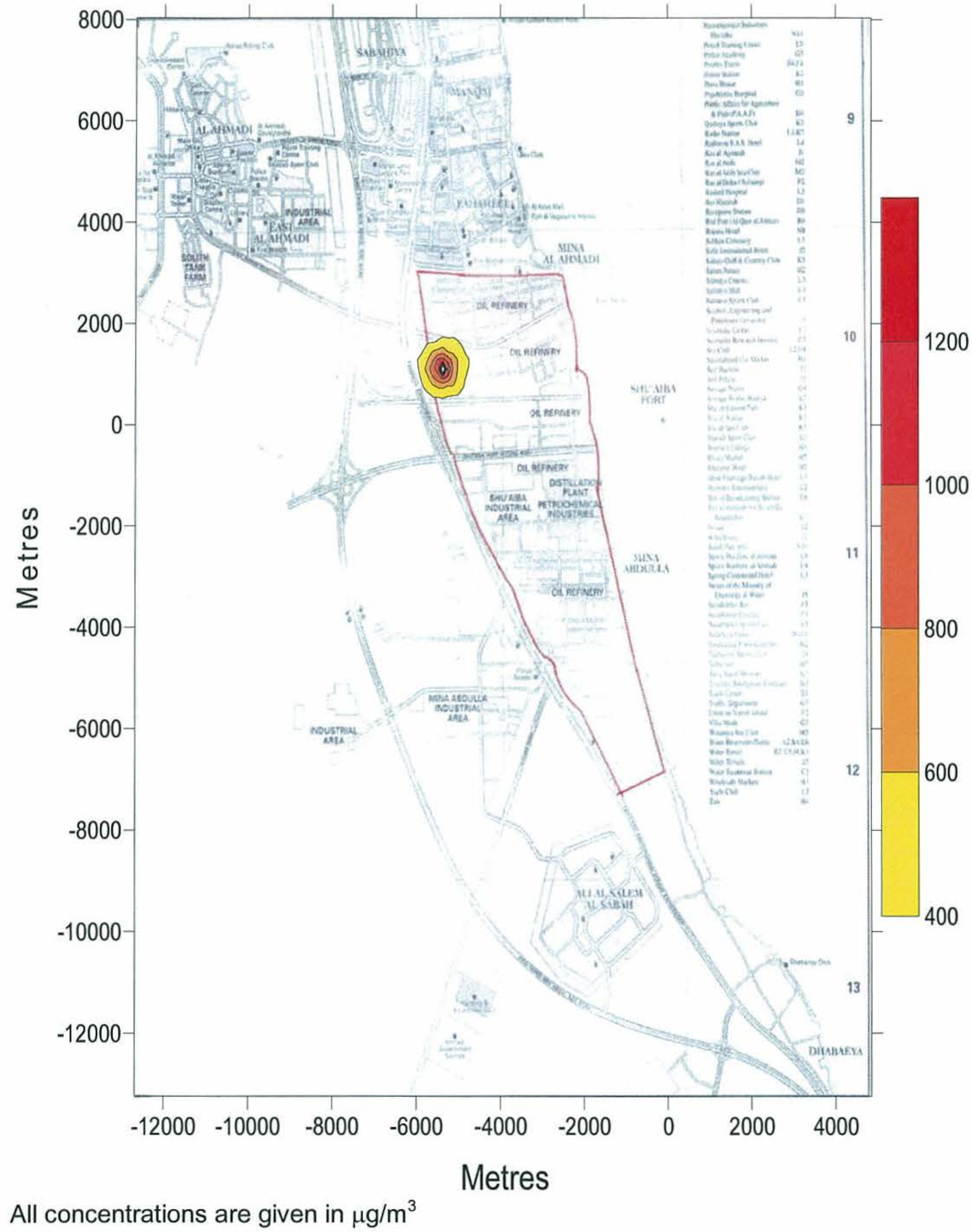
SO_2 (% against the Limit)	15 min avg (ST) 100th %ile	15 min avg (ST) 99.7th %ile	8 hr avg (LT) 100th %ile	8 hr avg (LT) 99.7th %ile
MAA	10%	6%	24%	14%
MAB	18%	11%	42%	25%

It can be seen that SO_2 levels satisfy the occupational exposure limits for 15 minutes OEL and 8 hour OEL, as this is a short term upset event, and concentrations of SO_2 will be considerably within criteria.

SO_2 concentrations also satisfy emergency response criteria at the site boundary.

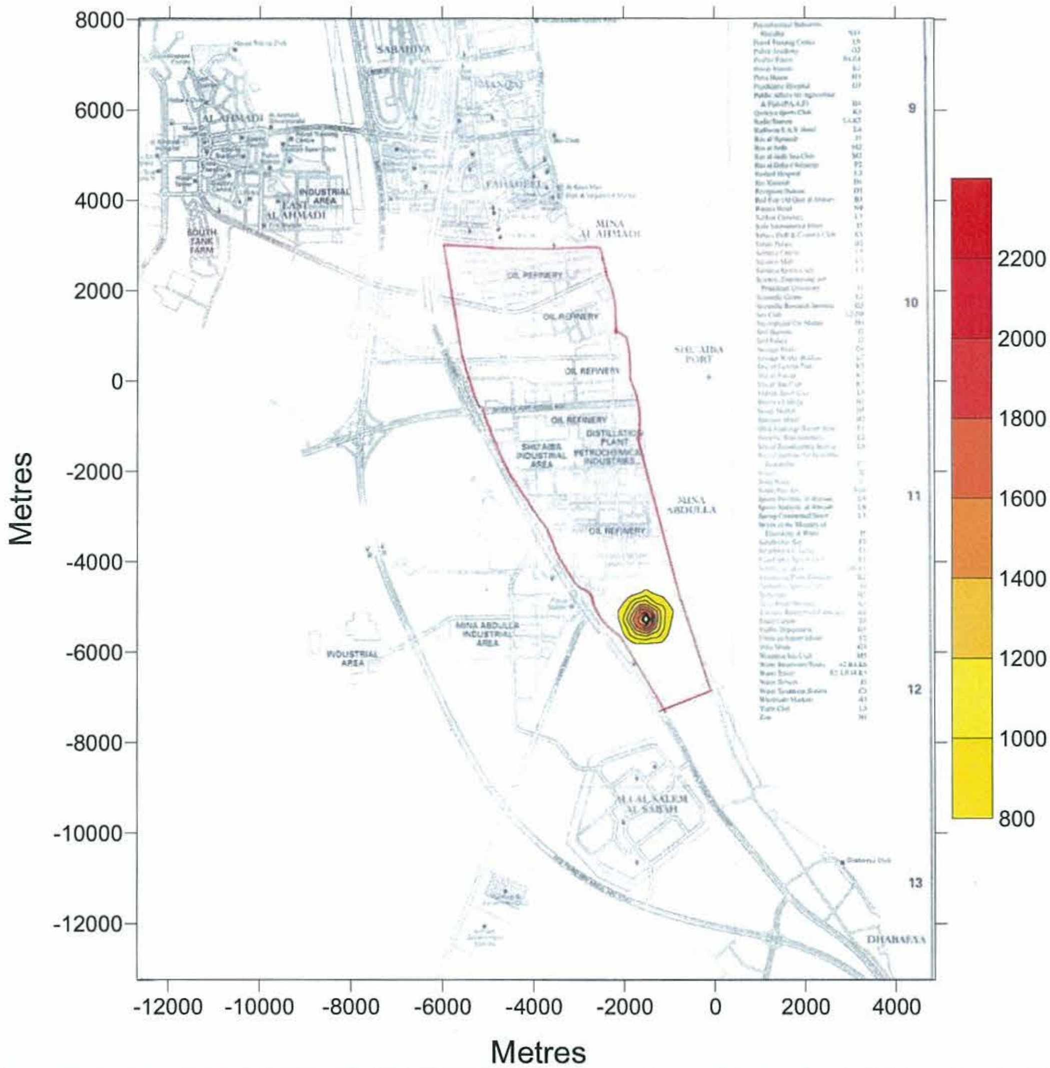
It is concluded that for SRU Upset Case 1, K-EPA / MOO criteria are satisfied. The short term dispersion contours (for SO_2) are presented in Figures 9-19 and 9-20. Note that the contours correspond to the 1-hour average concentrations, and do not include decommissioned scenario emissions. All concentrations are given in $\mu g/m^3$.

Figure 9.19: SO_2 100% percentile (SRU Upset Case 1- MAA)



All concentrations are given in $\mu g/m^3$

Figure 9.20: SO_2 100% percentile (SRU Upset Case 1- MAB)



All concentrations are given in $\mu g/m^3$

SRU Upset 2

The ground level maximum concentrations predicted anywhere for SO_2 and H_2S are summarised in Table 9.25 for MAA and MAB. Note that the decommissioned results have not been taken into account, as they are negligible compared against these emergency emissions.

Table 9.25: Maximum Ground Level Concentrations for H_2S and SO_2 Anywhere

All in μg/m³		100th %ile			99.7th %ile		
		1 hr	15 min avg	8 hr avg	1 hr	15 min avg	8 hr avg
MAA	SO_2	624	666	593	371	397	352
	H_2S	668	715	635	394	422	374
MAB	SO_2	1150	1231	1093	704	753	669
	H_2S	1220	1305	1159	745	797	708

Ground Level Concentrations of SO_2 satisfy occupational exposure criteria on site, as do H_2S levels (H_2S 1 hour occupational exposure criterion is approximately 20720 μg/m³).

Comparison against the occupational exposure criteria outlined in Table 9.16 is provided in the table below:

Table 9.26: Maximum Ground Level Concentrations Anywhere for H_2S and SO_2 as Percentage of the Criteria

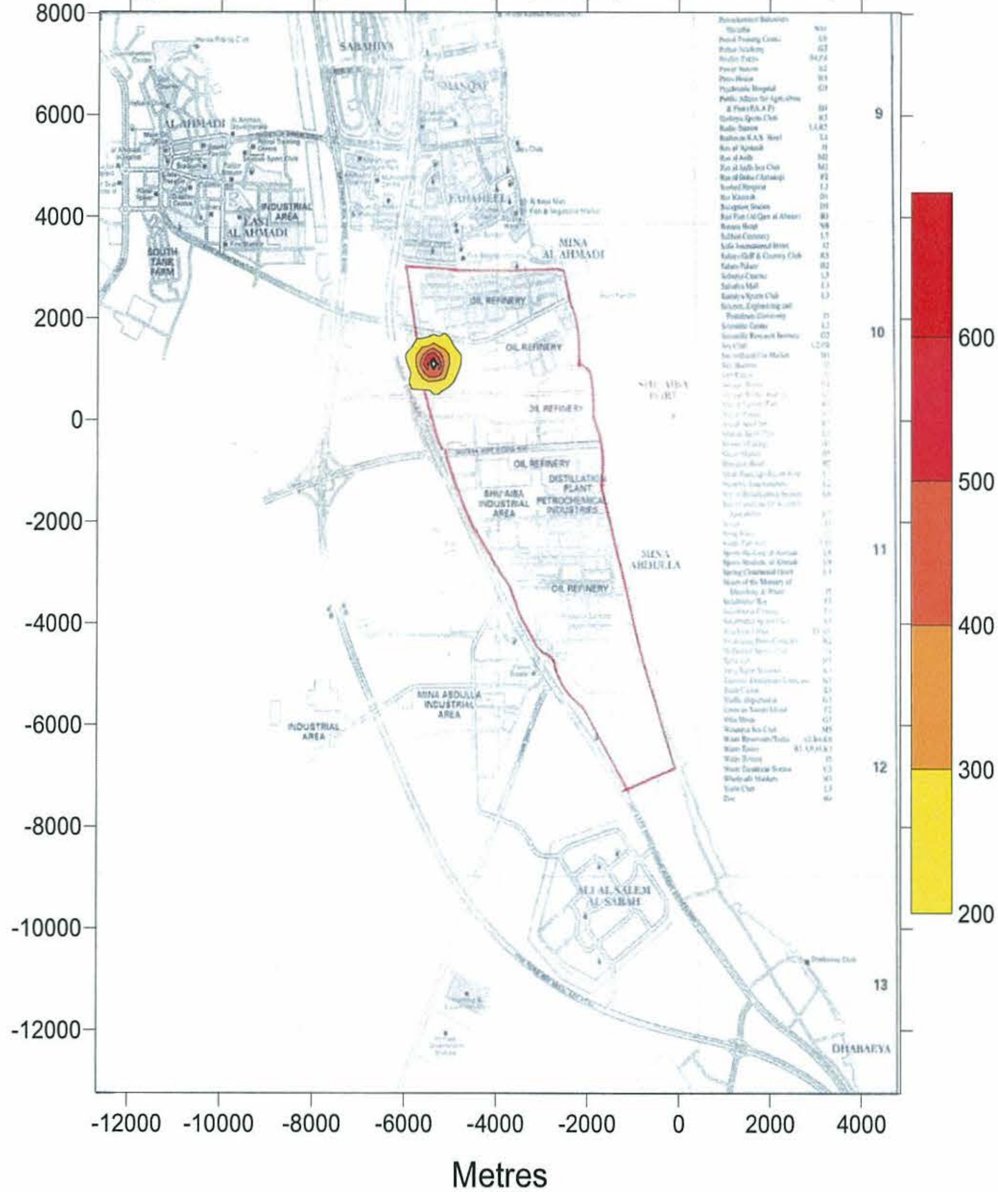
	% against the Limit	15 min avg (ST) 100th %ile	15 min avg (ST) 99.7th %ile	8 hr avg (LT) 100th %ile	8 hr avg (LT) 99.7th %ile
MAA	SO_2	5%	3%	12%	7%
	H_2S	3%	2%	5%	3%
MAB	SO_2	9%	6%	22%	13%
	H_2S	6%	4%	8%	5%

It can be seen that SO_2 and H_2S levels satisfy the occupational exposure limits, which are the appropriate ones for comparison as this is a short term upset event and concentrations of SO_2 and H_2S will be considerably within relevant K-EPA / MOO criteria.

SO_2 and H_2S concentrations also satisfy emergency response criteria at the site boundary.

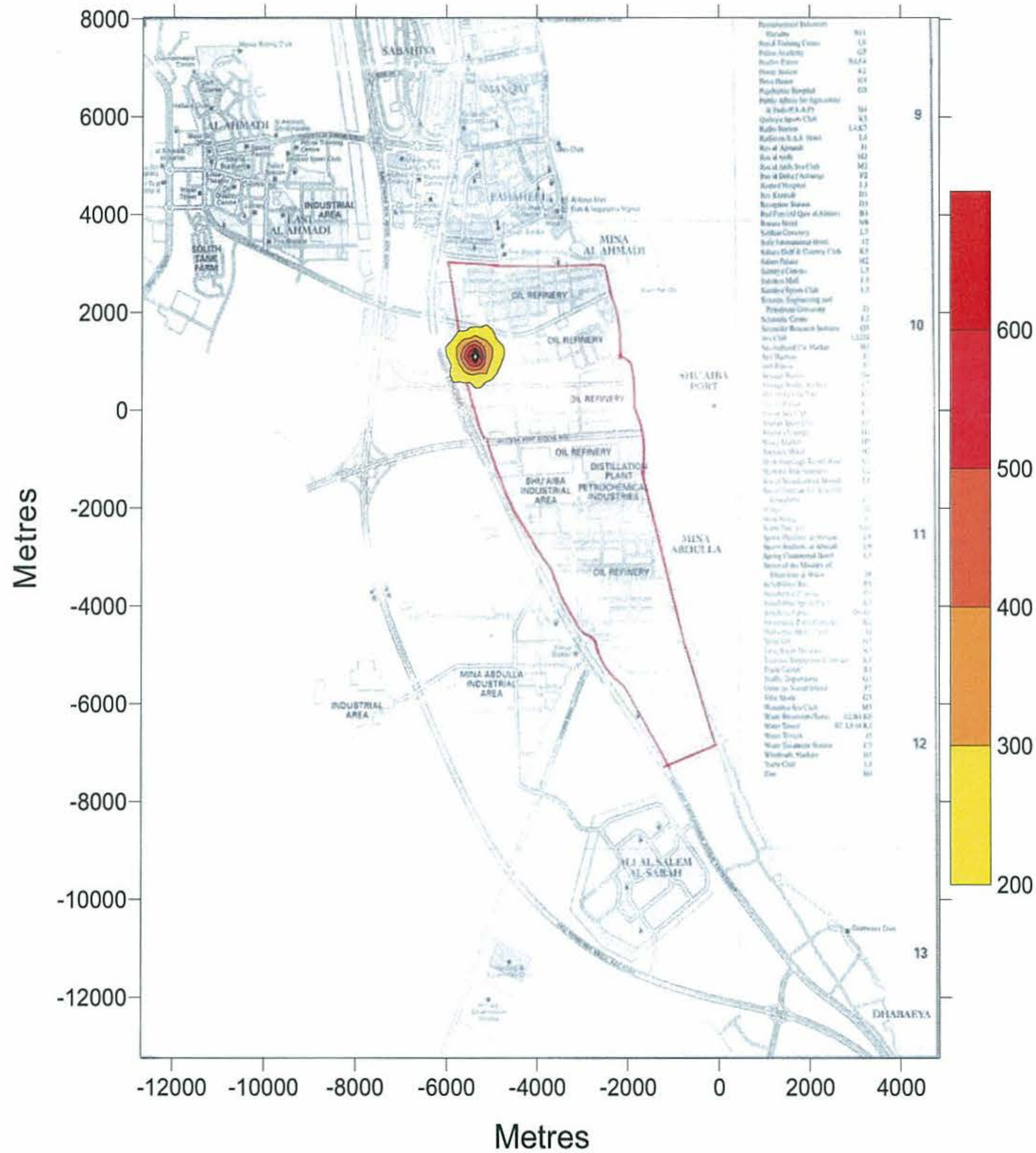
It is concluded that during an SRU Upset Case 2, impacts are managed satisfactorily. The short term dispersion contours are presented in Figures 9-21 through 9-24 below (100%ile) for both SO_2 and H_2S. Note that the contours correspond to the 1-hour average concentrations, and do not include decommissioned scenario emissions. All concentrations are given in μg/m³.

Figure 9.21: SO_2 100% percentile (SRU Upset Case 2 - MAA)



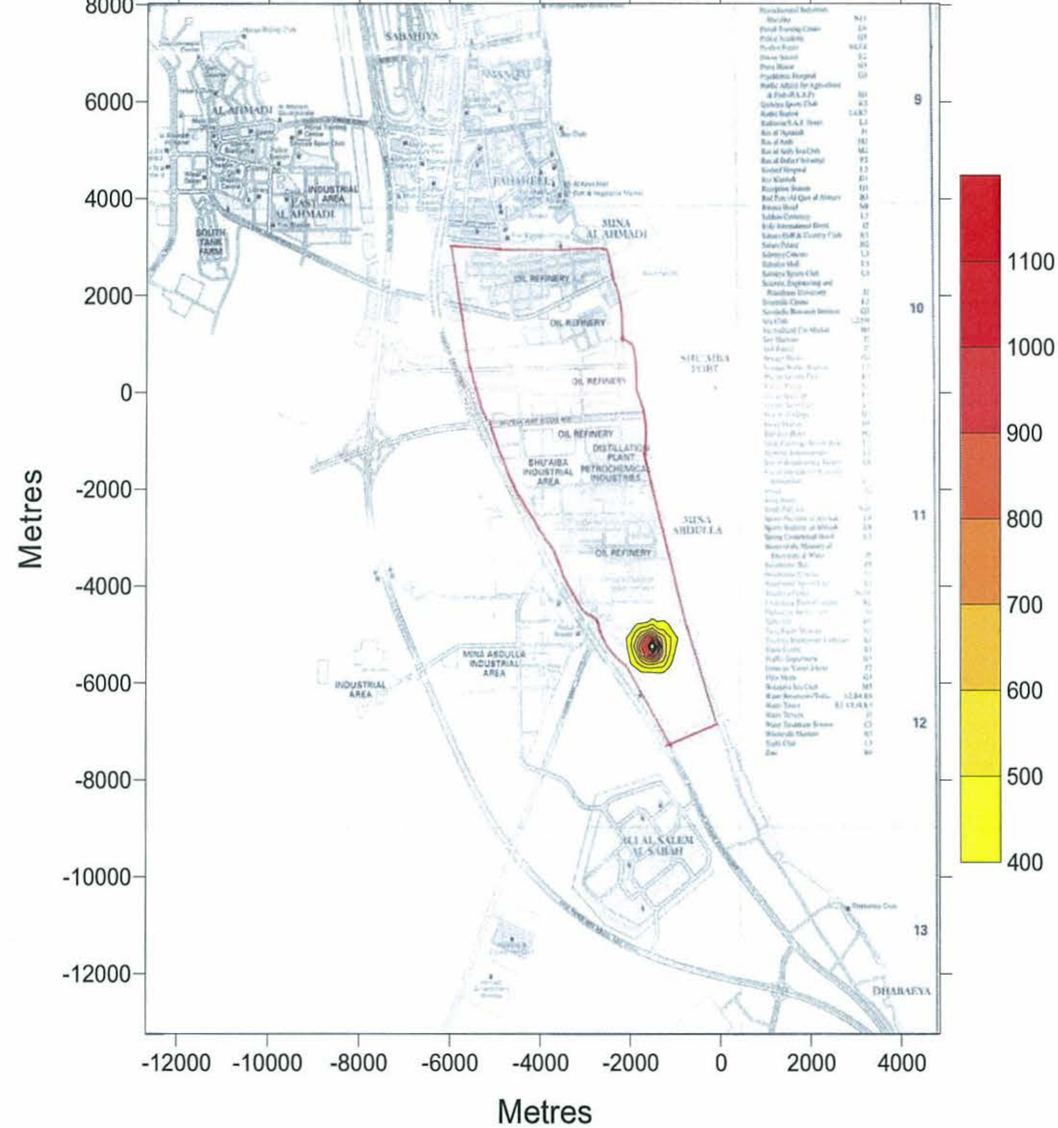
All concentrations are given in $\mu g/m^3$

Figure 9.22: H_2S 100% percentile (SRU Upset Case 2 - MAA)



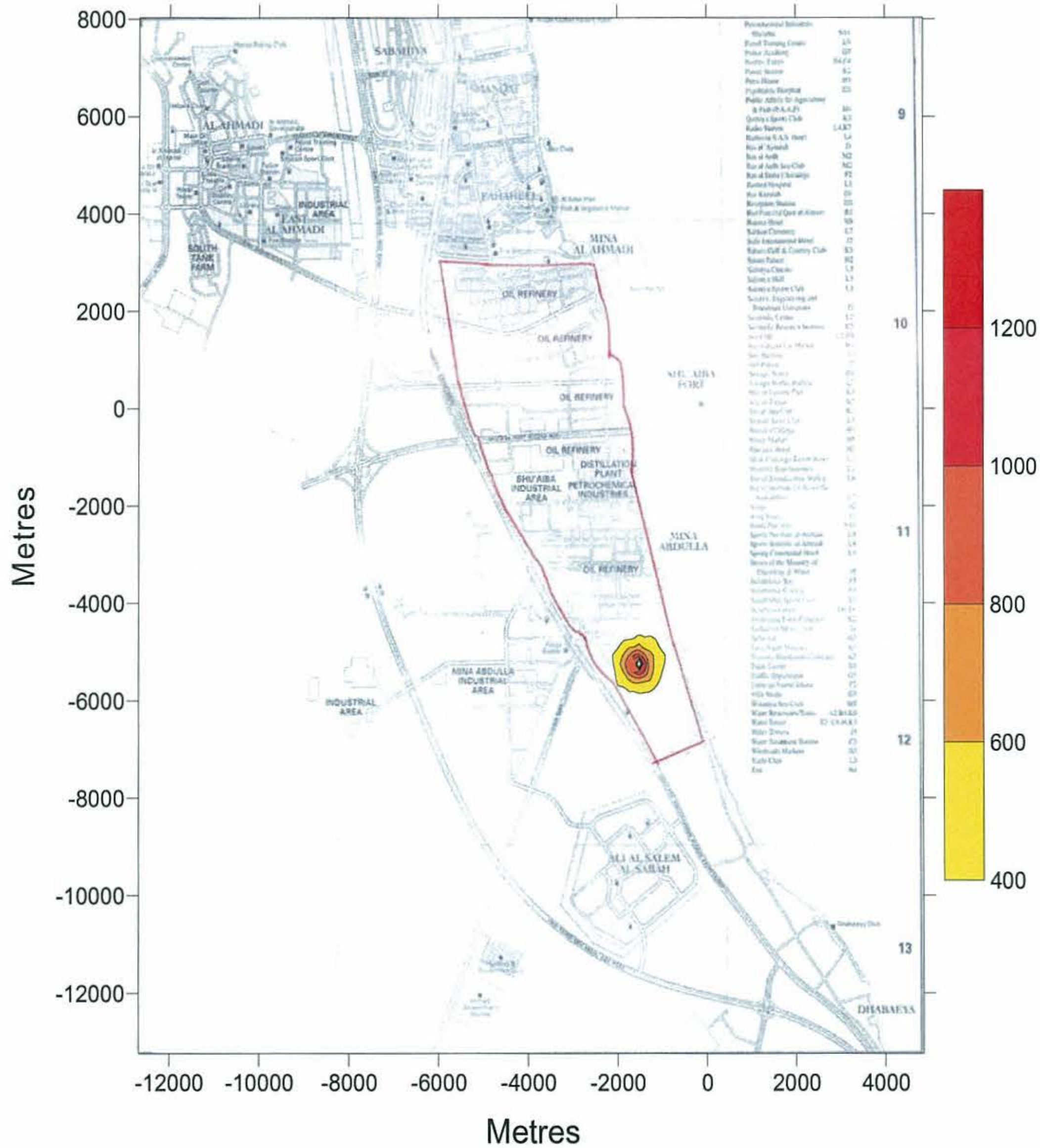
All concentrations are given in $\mu g/m^3$

Figure 9.23: SO_2 100% percentile (SRU Upset Case 2 - MAB)



All concentrations are given in $\mu g/m^3$

Figure 9.24: H_2S 100% percentile (SRU Upset Case 2 - MAB)



All concentrations are given in $\mu g/m^3$

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9.4.6.4 Emergency Flare Modelling

Significant flare emissions only take place during emergencies or upset conditions (such as power failure or upset scenarios at specific units). Emissions from emergency flaring have been modelled for both the new MAA and MAB acid and hydrocarbon gas flares, as well as the revamped flare systems at the MAA refinery. The emission data for the various scenarios considered are summarised in Table 9.11 and Table 9.12.

The key assumptions for deriving the necessary emission parameters are outlined in Section 9.4.3, and are briefly described below:

- Total combustion of the released stream (including 20% excess air)
- An exit velocity of 40 m/s (consistent with flare modelling guidelines)
- Calculating the flame height, which is included in the effective release height

The emergency flaring scenarios do not include the normal emissions from sources that will continue to operate during the emergency flaring event, or the decommissioned units' emissions. The pollutant contributions from these sources will be negligible in comparison to the emissions from the emergency flaring event.

Results from the emergency flaring scenarios modelled are presented in Table 9.27 for the converted maximum 15-minute average short-term concentrations of SO_2, for the 100^{th} and 99.7^{th} percentile (see Section 9.4.6.3 regarding methodology used for converting concentrations). The 100^{th} percentile is the concentration that is compared to the occupational exposure standards, whereas the 99.7^{th} percentile concentrations are provided for information only. Note that as for the SRU upset scenarios (see Section 9.4.6.3), the reported concentrations (100% and 99.7%ile for information only) are the factored (i.e. converting the 1-hour average to 15-minute average concentrations) maximum estimated, and do not include any normal emission or the decommissioned modelling results, as they are negligible in comparison.

Table 9.27 also includes the peak 100^{th} percentile 1-hour average short-term concentration of SO_2.

NO_2 modelling results are not indicated in the table, as they result in negligible Ground Level Concentrations (GLC) in relation to the relevant criteria.

Table 9.27: Maximum Concentrations for SO_2 Anywhere for Emergency Flaring Scenarios

Refinery / Flare	Tag No.	Emergency Scenario/Governing Case	Pollutant	Maximum GLC Concentration (1-hour average) (μg/m³)	Maximum GLC Concentration (Converted 15-minute averages) (μg/m³)	
				100%ile	100%ile	99.7%ile
MAA Unit 162	162-A-0101	Case 2	SO_2	1967	2105	1287
MAA Unit 167	167-A-0101	Case 2	SO_2	3675	3932	3485
MAA Unit 25/26	-	Case 2	SO_2	8.4	9	8
MAA Unit 39	ST-39-001	Case 1	SO_2	190	203	180
		Case 2	SO_2	870	931	669
		Case 4	SO_2	0.47	0.5	0.4
		Case 5	SO_2	547	585	294
MAB Unit 146	146-A-0101A	Case 2	SO_2	16727	17900	16326
MAB Unit 149 HP HC	149-A-0112A	Case 2	SO_2	2680	2866	2205
MAB Unit 149 LP HC	149-A-0102A	Case 2	SO_2	163.6	175	159
MAB Unit 249	249-A-0101	Case 2	SO_2	641	686	621
MAB Unit 314 HP HCR	314-A-0112A	Case 3	SO_2	108.4	116	102
MAA and MAB	TPF for all flares (Table 9.12)	TPF Combination	SO_2	4805	5141	4495

These results are then compared to the relevant occupational exposure limits, as set out in Table 9.16, to assess whether the maximum ground level concentrations (converted from 1-hour average to 15-minure average concentrations) estimated comply with OEL criteria. Table 9.28 summarises the ratios of the estimated concentration against the relevant occupational exposure limit. Exceedances are highlighted in red.

Table 9.28: Maximum Ground Level Concentrations Anywhere for SO_2 against Criteria (Flaring Scenarios)

Refinery / Flare	Tag No.	Emergency Scenario/Governing Case	Pollutant	Ratio of Concentration Against Criteria	
				100%ile	99.7%ile
MAA Unit 162	162-A-0101	Case 2	SO_2	0.16	0.10
MAA Unit 167	167-A-0101	Case 2	SO_2	0.30	0.27
MAA Unit 25/26	-	Case 2	SO_2	0.0007	0.0006
MAA Unit 39	ST-39-001	Case 1	SO_2	0.02	0.01
		Case 2	SO_2	0.07	0.05
		Case 4	SO_2	-	-
		Case 5	SO_2	0.05	0.02
MAB Unit 146	146-A-0101A	Case 2	SO_2	1.38	1.28
MAB Unit 149 HP HC	149-A-0112A	Case 2	SO_2	0.22	0.17
MAB Unit 149 LP HC	149-A-0102A	Case 2	SO_2	0.01	0.01
MAB Unit 249	249-A-0101	Case 2	SO_2	0.05	0.05
MAB Unit 314 HP HCR	314-A-0112A	Case 3	SO_2	0.01	0.01
MAA and MAB	TPF for all flares (Table 9.12)	TPF Combination	SO_2	0.40	0.35

Note: 1. The cells highlighted in red indicated exceedance against the applicable K-EPA / MOO criteria.
2. The ground level concentrations of NO_2 are not included in the table, as they result in < 5% of criterion.

As shown in Table 9.28 the occupational exposure standards for SO_2 are exceeded for the acid gas flare at MAB (Unit 146). Closer investigation of the results indicates that the occupational exposure standard for sulphur dioxide is exceeded both within and beyond the refinery boundary.

All other cases satisfy the occupational exposure standard for SO_2, although significant ground level concentrations are still experienced off-site, beyond the refineries boundary, particularly for the flares associated with Units 162 and 167 at MAA refinery, Units 146 and 149 HP HC at MAB refinery, as well as the Total Power Failure flaring case.

The ground level, offsite concentrations of sulphur dioxide are discussed in the context of the ERPG-2 and AEGL-2 criteria in the section that follows.

9.4.6.5 Off-site Exposure

Despite the fact that the occupational exposure criteria for sulphur dioxide are satisfied on-site (with the exception of the acid gas flare at MAB, Unit 146), some consideration has to be given for the resulting ground level pollutant concentrations beyond the fence-line of the refineries. This is particularly relevant for the residential area South-East of MAB which is very near the fence line of the refinery.

There is a relative conservatism in the emergency flaring modelling, where the scenarios have been modelled as continuous releases, when in fact they are expected to last less than an hour, and will occur only during emergencies and very infrequently (as per Fluor / KNPC information). The relevant K-EPA criteria for off-site air quality are applicable to the 99.7%ile ground level sulphur dioxide concentration. This allows for 26 exceedances per year, hence it can be said that since these emergency flaring events are anticipated to occur less than once a year, the K-EPA off-site air quality requirements are also satisfied.

On the other hand, it is important to acknowledge the fact that concentrations beyond the refinery fence-lines will exceed (particularly for the flares associated with Units 162, 167, 146, 149 HP HC and the Total Power Failure Case based on the current design flare load and stack height) the US AEGL-2 (Acute Exposure Guideline Levels) criterion for sulphur dioxide.

The acid gas flare at MAB (Unit 146) will also exceed the US ERPG-2 (US Emergency Response Planning Guidelines) criterion for sulphur dioxide.

These criteria, which in the absence of any guidelines / criteria from K-EPA / MOO are deemed to be the more appropriate ones to be used beyond the refinery fence-line for this kind of emergency events, are briefly explained below:

- ERPG values intend to provide estimates of the concentrations at which most people will begin to experience health effects if they are exposed to a toxic chemical for one (1) hour. Note that sensitive members of the public such as old, sick, or very young people are not covered by these guidelines and they may experience adverse effects at concentrations below the ERPG values. The ERPG-

2 value is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

- The US Acute Exposure Guideline Levels (AEGL) have been developed primarily to provide guidance in situations were there can be a rare, typically accidental exposure to a particular chemical that can involve the general public. AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

The ERPG-2 and AEGL-2 criteria for sulphur dioxide are summarised in the table below.

Table 9.29: ERPG-2 and AEGL-2 Criteria for Sulphur Dioxide

Pollutant	ERPG-2 Criterion ppm (μg/m³)	AEGL-2 Criterion ppm (μg/m³)
SO_2	3 (7600)	0.75 (1900)

Assumes an ambient air temperature of 35°C

As a result the effects on population would be significant (if generally reversible) for the worst flare emergency scenarios (Units 162, 167, 146, 149 HP HC and the Total Power Failure Case), where the AEGL-2 criterion is exceeded.

Additional modelling was conducted for the emergency scenario involving the MAB refinery flares associated with Units 146 and 149 HP HC, as well as MAA refinery flares at Units 162 and 167. The total power failure case was also revised to account for the change in stack heights for the aforementioned flare units. In addition to that, the total power failure case considered an additional sensitivity with the stack height of the flare associated with Unit 62, as it has the highest release rate of sulphur dioxide (see Table 9.12).

The additional modelling (i.e. sensitivity cases) is discussed in the section that follows.

9.4.6.6 Emergency Flare Sensitivity Modelling

The aim of the sensitivity analysis is to examine the effect of increasing the stack height for the flaring events that currently exceed the AEGL-2 (and ERPG-2 for Unit 146) criterion for sulphur dioxide. Note that this refers to the peak 100th percentile 1-hour average short-term concentration of SO_2.

The following sensitivity cases were considered:

- For MAA Unit 162 the flare stack height has been increased to 128 m (from 108 m).
- For MAA Unit 167 the flare stack height has been increased to 141 m (from 91 m).
- For MAB Unit 146 the flare stack height has been increased to 141 m (from 36.6 m). Note that this flaring scenario currently exceeds the OEL standards on-site as

well as off-site, and significantly exceeds both the ERPG-2 and AEGL-2 criteria for SO_2 off-site.

- For MAB Unit 149 HP HC the flare stack height has been increased to 110 m (from 61 m).
- The total power failure case was revised to account for the flare stack heights mentioned above, and with the stack height for Unit 62 increased to 150 m, as opposed to the current height of 110 m. The flare associated with Unit 62 has the highest release rate of sulphur dioxide (see Table 9.12). (Note that the stack height used for Unit 149 HP HC was 100 m).

Only the stack height (and hence the effective height) of the flare is changed for these sensitivities, with the rest of the modelling parameters remaining the same (see Table 9.11 and Table 9.12).

Results from the sensitivity analysis are presented in Table 9.30 for the maximum 1-hour average short-term concentrations of SO_2 (i.e. 100th percentile). The 100th percentile is the concentration that should be compared to the ERPG-2 and AEGL-2 standards. The reported concentrations do not include any normal emissions or the decommissioned modelling results, as they are negligible in comparison.

Table 9.30: Maximum Concentration Levels for SO_2 Anywhere - Sensitivity Analysis

Refinery / Flare	Tag No.	Flare Stack Height (m)	Emergency Scenario	Pollutant	Maximum GLC Concentration (1-hr average) (μg/m³)
MAA Unit 162	162-A-0101	128	Case 2	SO_2	1907
MAA Unit 167	167-A-0101	141	Case 2	SO_2	2640
MAB Unit 146	146-A-0101A	141	Case 2	SO_2	4386
MAB Unit 149 HP HC	149-A-0112A	110	Case 2	SO_2	1425
MAA and MAB	TPF for all flares (Table 9.12)	As for base case, with Unit 162 stack height set at 128 m, Unit 167 at 141 m, Unit 149 HP HC 100 m, for Unit 146 at 141 m, and for Unit 62 at 150 m.	TPF Combination	SO_2	3530

The sensitivity analysis results indicate that:

- The maximum ground level concentration of sulphur dioxide for all flare emission scenarios, including the TPF case, now meet the OEL criterion.
- The maximum ground level concentration of sulphur dioxide for all flare emission scenarios, including the TPF case, now meet the ERPG-2 criterion.
- Flare emissions Units 162 and 149 HP HC satisfy the stricter AEGL-2 criterion for sulphur dioxide.
- For the new acid gas flares at MAA (Unit 167) and MAB (Unit 146), the AEGL-2 criterion for sulphur dioxide will be exceeded beyond the refineries fence-line, even at the revised height 141 m.
- The revised combined TPF case, when accounting for the different stack heights of flares at MAA and MAB, improves from the base case, with the resulting sulphur dioxide ground level concentration still exceeding the AEGL-2 criterion. Unit 62 is the main contributor of sulphur dioxide emissions to the TPF case.

The key outcome from the sensitivity analysis is that further work should be conducted in order to investigate the peak ground level sulphur dioxide concentrations from Units 146, 167 and 62 (associated with the TPF case only). The peak concentration results for these units currently exceed the AEGL-2 criterion for sulphur dioxide beyond the refineries boundary.

Detailed modelling of the emergency flare scenarios should be conducted during the detailed design / EPC stages of the project, as these results are based only on preliminary data available.

Additional sensitivity analysis was conducted on the emergency flaring scenarios that currently exceed the AEGL-2 criterion for sulphur dioxide (i.e. Case 2 for MAB Unit 146 and MAA Unit 167, as well as the TPF case). The parameter investigated was the emission rate of sulphur dioxide: Three (3) additional flaring preliminary sensitivity cases were considered for the aforementioned emergency cases, assuming that the current SO_2 emission rates were halved, and all other modelling parameters remain the same. Note that for the TPF case, only the SO_2 emission rate from the flare associated with existing MAA Unit 62 was halved (Unit 62 contributes the highest SO_2 emission rate to the TPF scenario), with the emission rates for all other flares remaining as indicated in Table 9.12. The flare stack heights for TPF, MAB Unit 146 and MAA Unit 167 remain as indicated in Table 9.30.

The results indicate that with the emission rate of sulphur dioxide halved, the resulting peak ground level concentrations will reduce proportionally. This would result in MAA Unit 167 Case 2 and the TPF case meeting the AEGL-2 criterion. MAB Unit 146 Case 2 would still not meet the AEGL-2 criterion. In order for this case to meet the AEGL-2 criterion, the emission rate of sulphur dioxide should be reduced to approximately 35-40% of its current value.

9.4.6.7 VOC Fugitive Emissions

This section summarizes the modeling of VOC fugitive emissions from storage tanks in hydrocarbon service (see Appendix I), as part of the CFP project. A total of 250 tanks were modelled across all three refineries.

The breakdown of tanks from each refinery is as follows:

- 101 from MAA
- 83 from MAB
- 66 from SHU

VOC fugitive emissions from the tanks were modelled using the TANKS program (version 4.09). The program was designed by the U.S. Environmental Protection Agency's (EPA) Office of Air Quality Planning (OAQPS) for use in estimating air emissions from organic liquids in storage tanks. The OAQPS develops and maintains emission estimating tools to support public (Federal, State and Local Agencies) and private sector (industry) institutions in the estimation of air emissions. The underlying theory behind the emissions estimating equations that form the basis of the tanks software program were developed by the American Petroleum Institute (API) and can be found in AP-42 "Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources" Section 7.1, Organic Liquid Storage Tanks.

The TANKS program generates an emission report based on user specified information about each storage tank. The report generated can include monthly or annual estimates for each chemical or mixture of chemicals stored in each tank. The input required includes but is not limited to

- Tank type (structural type, dimensions, paint condition),
- Liquid contents (chemical composition) and the
- Geographical location of each tank (ambient temperature, solar insulation factor, wind speed)

The program relies on a database that includes physical & chemical data on various chemicals which include organic liquids, petroleum distillates & crude oils. The database also contains meteorological information on over 175 US cities (Arizona was used to represent Kuwait in this study).

The results of the VOC fugitive emissions on an annual basis are outlined and discussed below, and are based on the total emissions from all tanks and the total area occupied by the tanks within a specific location. The tanks were separated into four (4) different areas of interest across the refineries. Figure 9.25 to Figure 9.27 show the locations of the relevant areas on the refinery plot plans.

Figure 9.25: Tank Area 1 – MAA Refinery

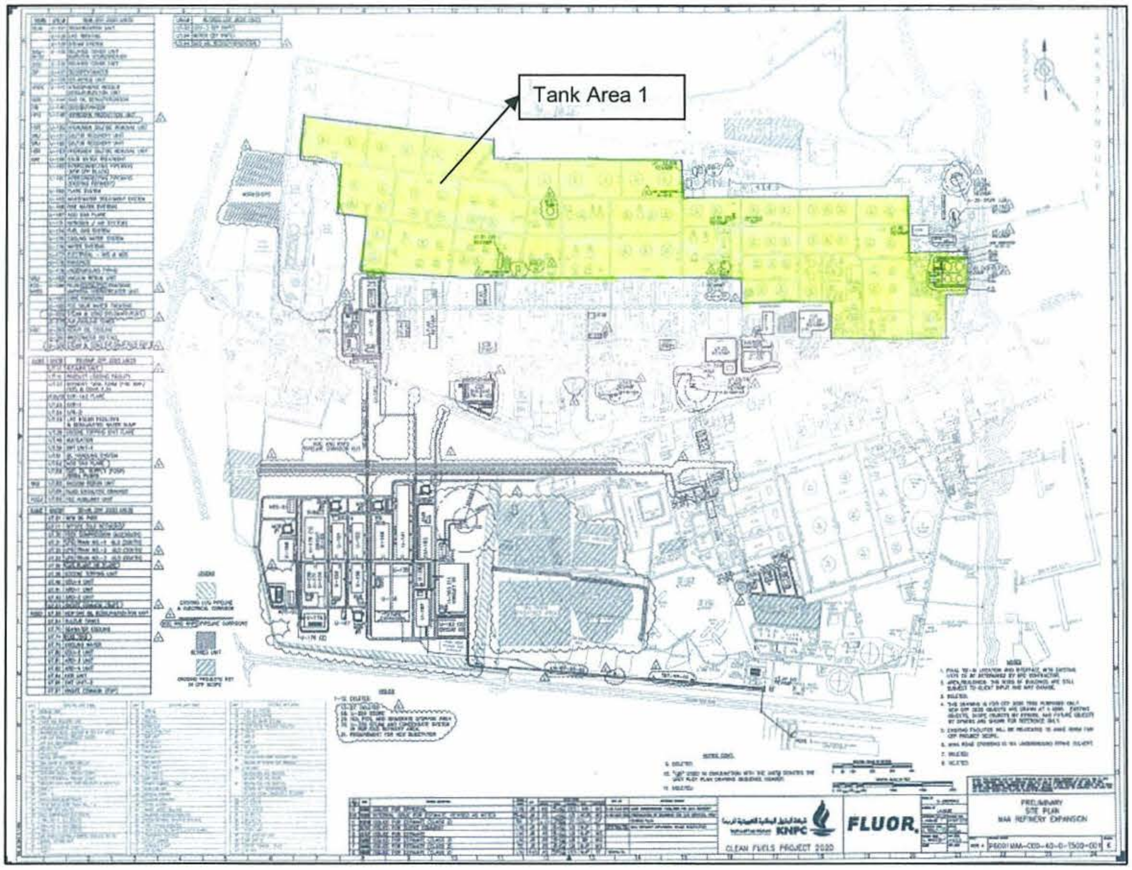


Figure 9.26: Tank Area 2 – MAB Refinery

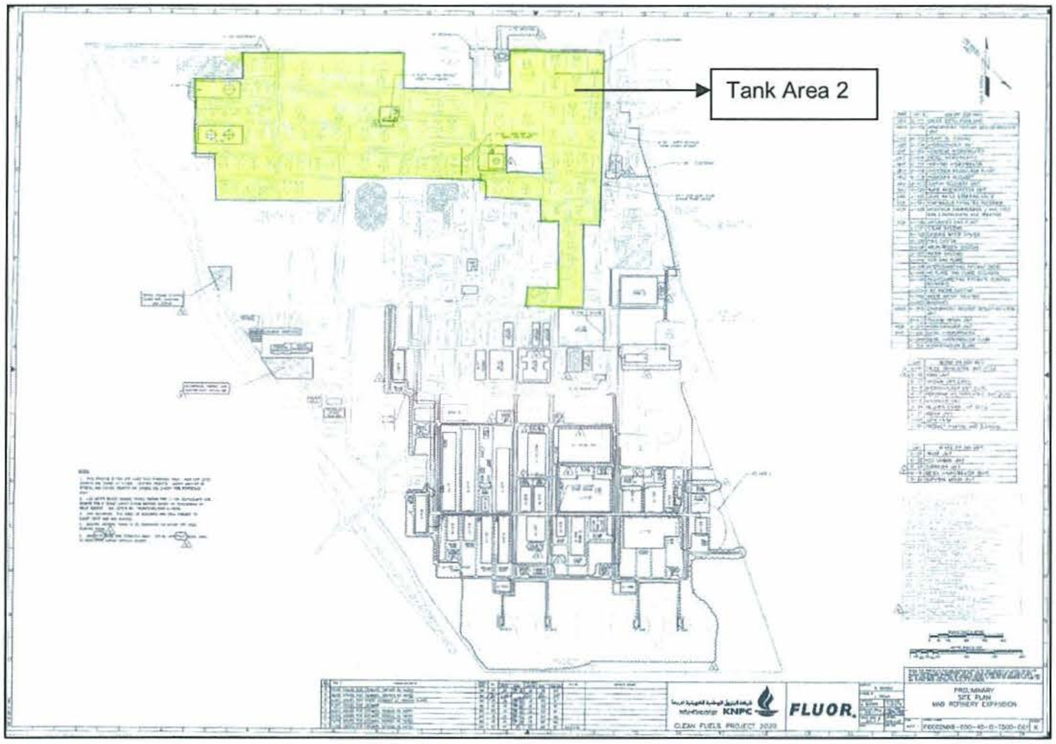
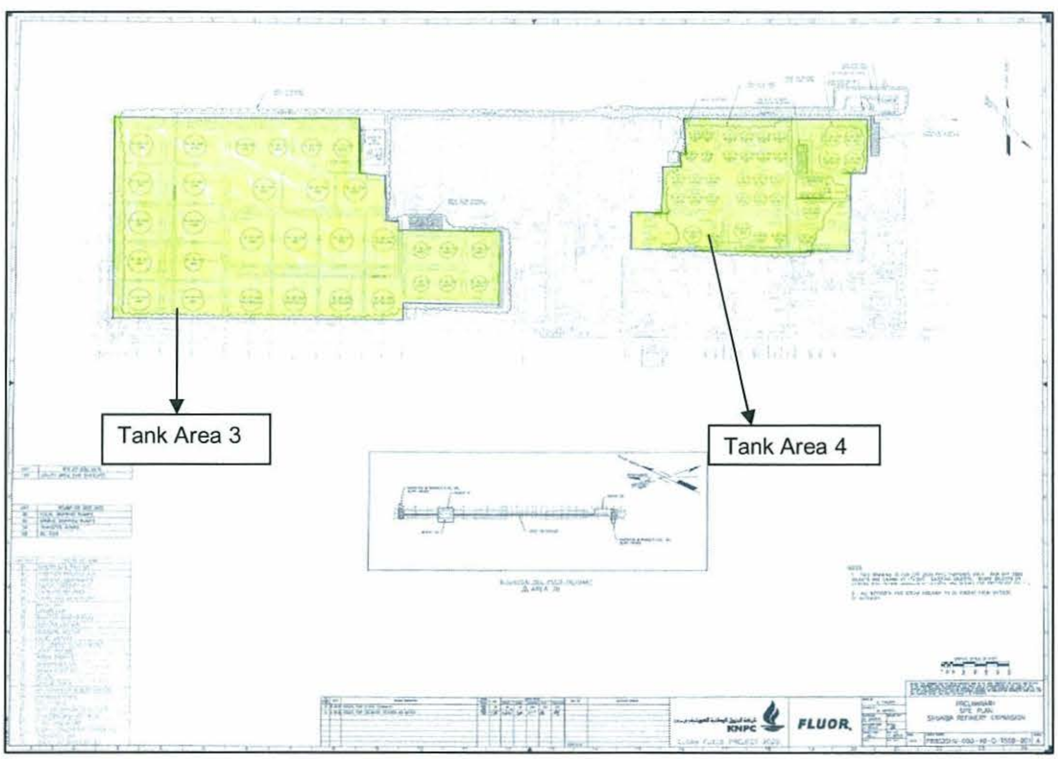


Figure 9.27: Tank Areas 3 & 4 – SHU Refinery



The key assumptions made for modeling purposes are summarised below:

- In the absence of detailed meteorological data for Kuwait in the TANKS program, Arizona was used because of the high similarity in meteorological conditions with Kuwait.
- The tank volume used to estimate the amount of VOC emissions was evaluated based on the actual dimensions of each tank. This was necessary to ensure consistency between the dimensions and volume of the tank.
- The chemical database in the TANKS program, though exhaustive, does not contain data on every single chemical substance. In instances where the material stored in the tanks was not available in the TANKS database, the material modelled in TANKS was selected using the following assumptions;
    - If Relative Vapour Pressure (RVP) data was provided for the material, a material with a similar RVP in TANKS was used
    - If no RVP data was available, the material that most closely matched the description was selected. For example "Jet kerosene" was used to model "Kerosene"
- Tank TK-34-342 at Shuaiba (SHU) refinery has been conservatively included as a vertical fixed roof tank, with the turnover data provided (it is actually an external floating roof tank but no turnover data were available).
- Tanks TK-52-109N/110N, TK-50-159 and TK-52-170/174, indicated as external floating roof tanks in the supplied data, have not been included in the modeling, because of the limited data available.
- Tanks 61-T-0103/0104 at MAA refinery have not been included in the modeling as they are not atmospheric tanks (as per Fluor supplied information these tanks are pressurised and only vent to atmosphere in case of fire).

The modelling results for the tank VOC fugitive emissions are divided over the relevant tank areas to obtain the area emission rate, for input in ADMS. Table 9.31 summarises the total emissions per unit area based on the relative tank areas defined above.

Table 9.31: Tank Grouping, Areas Covered, VOC Emission Rates & Concentrations

Area[1]	No. Of Tanks	Location	Total Emission[2] (g/s)	Total Estimated Tank Area (m^2)	Emission Rate ($g/m^2/s$)
1	101	MAA	22.5	1,790,000	1.26E-05
2	83	MAB	7.3	1,185,000	6.16E-06
3	31	SHU	4.3	690,700	6.23E-06
4	35	SHU	4.7	222,000	2.12E-05

Notes: 1. See Figures 9-26 to 9-28.
2. The total emission by tank area is based on *yearly* emissions report from TANKS.

The above emission data were entered in ADMS in order to determined resulting VOC ground level concentrations anywhere on facilities and the surrounding areas. The height for all tank areas considered is estimated to be 60 ft (approximately 18m), with the temperature of the release assumed to be 40°C. The default molecular weight of around 29 is assumed for the releases (note that tank emissions will not be pure VOC vapour).

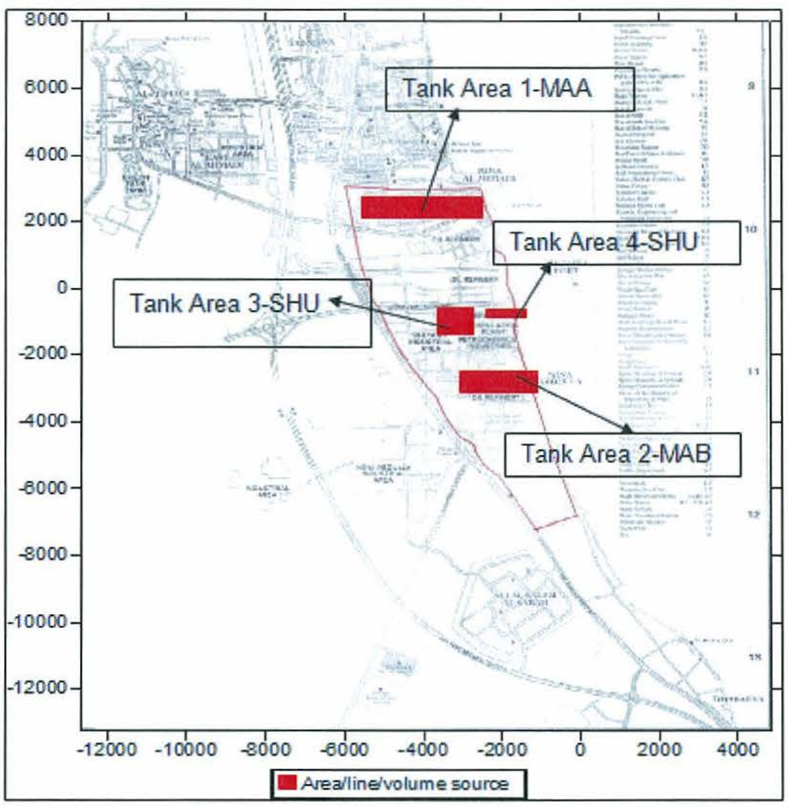
The four different tank areas identified have been entered in ADMS as area sources, and are approximated as rectangles of the equivalent area. The areas are illustrated in Figure 9.28.

Three models were considered in ADMS, namely:

- Specifying the exit velocity directly for each tank area identified, and assuming values of 0.2 and 0.001 m/s (i.e. two separate cases). The latter exit velocity value is referenced by the US EPA.
- Additionally, a conservative exit velocity of 0 m/s was considered, though the actual exit velocity for these VOC emissions will be negligible. Hence the dispersion of pollutants will be driven by the weather (rather than the initial effects of the exit velocity).

It is also noted that statistical meteorological data were used to run the ADMS model.

Figure 9.28: Location of AMDS Area Sources for Tank VOC Model



The ground level, maximum, 100%ile, 1-hour average and annual average VOC concentrations predicted for the three ADMS runs considered anywhere within the facilities and their surrounding areas are summarised in Table 9.32:

Table 9.32: Maximum Ground Level Concentrations of VOCs Anywhere

Model / Case	Pollutant	ST Concentration µg/m³ (100th %ile)	LT Concentration µg/m³
Specified Exit Velocity (0 m/s)	VOC	67	20
Specified Exit Velocity (0.2 m/s)		6	3.5
Specified Exit Velocity (0.001 m/s)		63.2	19

K-EPA and MOO criteria for non-methane hydrocarbons are as follows:

- 1/10 from specified rate in works environment (TLV`s). This is considered to be 10% of the occupational exposure limit, which would equate to 0.05ppm for benzene (equivalent to 158 $\mu g/m^3$)
- 0.24ppm for 3 hours 6-9am (equivalent to 780 $\mu g/m^3$)
- 100ppb (1 hour average) (equivalent to 324 $\mu g/m^3$)

Given the results from the modeling, it is clear that the highest estimated 100%ile, 1-hour average VOC concentration anywhere is significantly below (just over 40%) the most stringent VOC criterion for non-methane hydrocarbons specified above (158 $\mu g/m^3$).

Based on these results it can be concluded that VOC emissions from the tanks associated with this project satisfy all the relevant K-EPA / MOO criteria.

Since fugitive emissions from hydrocarbon storage tanks are essentially averages over long periods of time (e.g. annually, monthly) a comparison was made of the long term VOC modeling results (i.e. annual) against relevant long term criteria. In the absence of long term K-EPA VOC criteria, a comparison was made against incoming EU long term human health criteria (annual, no exceedances allowed) for benzene for 2010 of 5 $\mu g/m^3$. Maximum concentrations exceed criteria, though it should be noted that benzene constitutes a negligible part of the overall VOC emissions.

However, the USEPA IRIS Reference Concentration (RfC) of 30 $\mu g/m^3$, which is the concentration at which a lifetime's exposure is not expected to have an adverse effect, is met by the KNPC refinery tank emissions (daily inhalation exposure). Note that the RfC concentration is an estimate associated with large uncertainty.

However, in addition to the emissions from storage tanks shown above, fugitive emissions from process equipment (flanges, valves, pump seals etc) represent another substantial source of VOC`s emitted to the atmosphere from the refinery and can frequently account for 50% of the total emissions from a refinery (IPPC Reference Document on BAT for Mineral Oil and Gas Refineries, February 2003). Therefore, the total VOC emissions estimated from the tanks may only represent 50% of the total emissions from the refinery, although fugitive emissions from process plant will not necessarily take place in the same physical area as the tanks.

KNPC have committed to a Leak Detection and Repair (LDAR) Programme, as well as an Odour Management System (OMS) to minimize VOC emissions. These are further discussed in subsequent sections of this EIS. The new CFP facilities will be incorporated within the existing refineries LDAR Programme and OMS System.

9.4.6.8 RMP and CFP Block Maintenance Scenarios

The following two maintenance events scenarios for MAA have been modelled with "Normal Emissions" and combined with emissions from the Decommissioned units:

Maintenance 1: Shutdown of RMP Block would result in only sour fuel gas to be available to MAA Isomerization Unit 107 (two fired heaters). Consequently there would be an increase in SO_2 emissions during operation of CFP 2020 facilities. However, fired equipment within the RMP block will not operate, partially offsetting the increased SO_2 emissions from Unit 107.

Maintenance 2: Shutdown of CFP Block would result in only sour fuel gas to be available to MAA Deisopentanizer Unit 137 (one fired heater) that would result in increased SO_2 emissions. Fired equipment within the CFP block will not operate partially offsetting the increased SO_2 emissions from Unit 137.

Both these events are anticipated to last for up to 30 days, and occur once every four to five years. During the maintenance period, the concentration of H_2S in the fuel gas being consumed by the fired equipment in either Unit 107 or Unit 137 (approximately 1500 mg/dry m^3 at normal conditions) will exceed K-EPA Appendix 20 criteria (230 mg/dry m^3) However, the SO_2 emission rate will still be well below the applicable K-EPA limit (512 ng/J). The potential impacts of the 'above normal' SO_2 emissions for the two maintenance cases were evaluated by air dispersion modelling analysis in consideration of the applicable K-EPA / MOO ambient air quality criteria. For air dispersion modelling purposes, the emissions were assumed to be steady state. It is unlikely that the two maintenance events will occur simultaneously.

The emission data for the maintenance scenario are provided in Table 9.14. Normal case emission with decommissioned units emissions have been modelled together with each of the maintenance scenarios.

It is noted here that NO_2 and H_2S modelling results are not indicated in the tables as their emissions are minimal during these maintenance scenarios.

<u>Maintenance 1: Shutdown RMP Block</u>

During the RMP block shutdown, the specific fired equipment that would be shutdown is listed in Table 9.14 (i.e. one new unit and ten existing units in MAA). The locations of the 10 existing units in MAA were approximated for ADMS input.

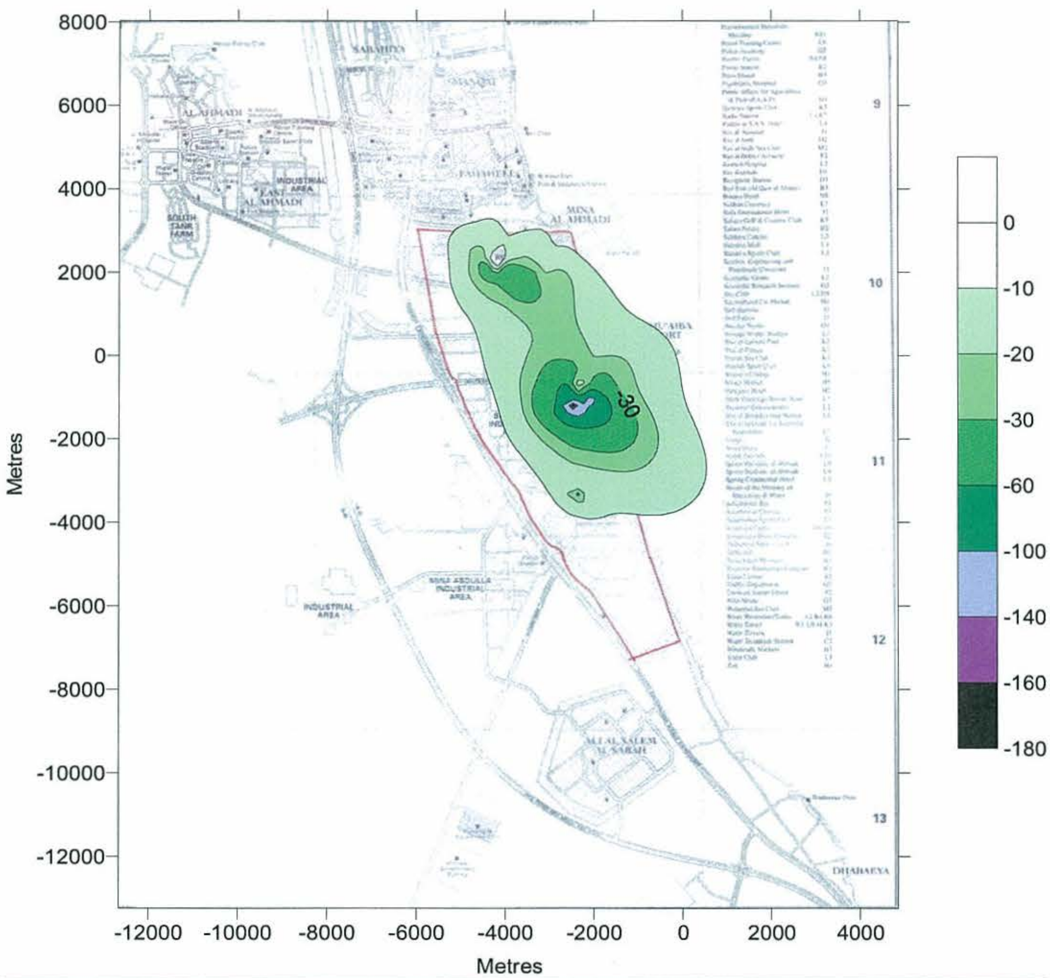
The long term (annual average) and short term (99.7%ile 1 hour average) SO_2 ground level concentration contours results are presented in Figure 9.29 and

Figure 9.30 respectively.

It can be seen that the resulting ground level concentration contour plots for sulphur dioxide are very similar to the Normal Base Case contour plots. Hence it is expected that post-CFP air quality would generally improve in the area.

In conclusion, during RMP block maintenance, the resulting ambient SO_2 concentrations would be within the K-EPA / MOO air quality criteria.

Figure 9.29: SO2 Annual average (Combined – Base Case) – Maintenance 1



All concentrations are given in $\mu g/m^3$.

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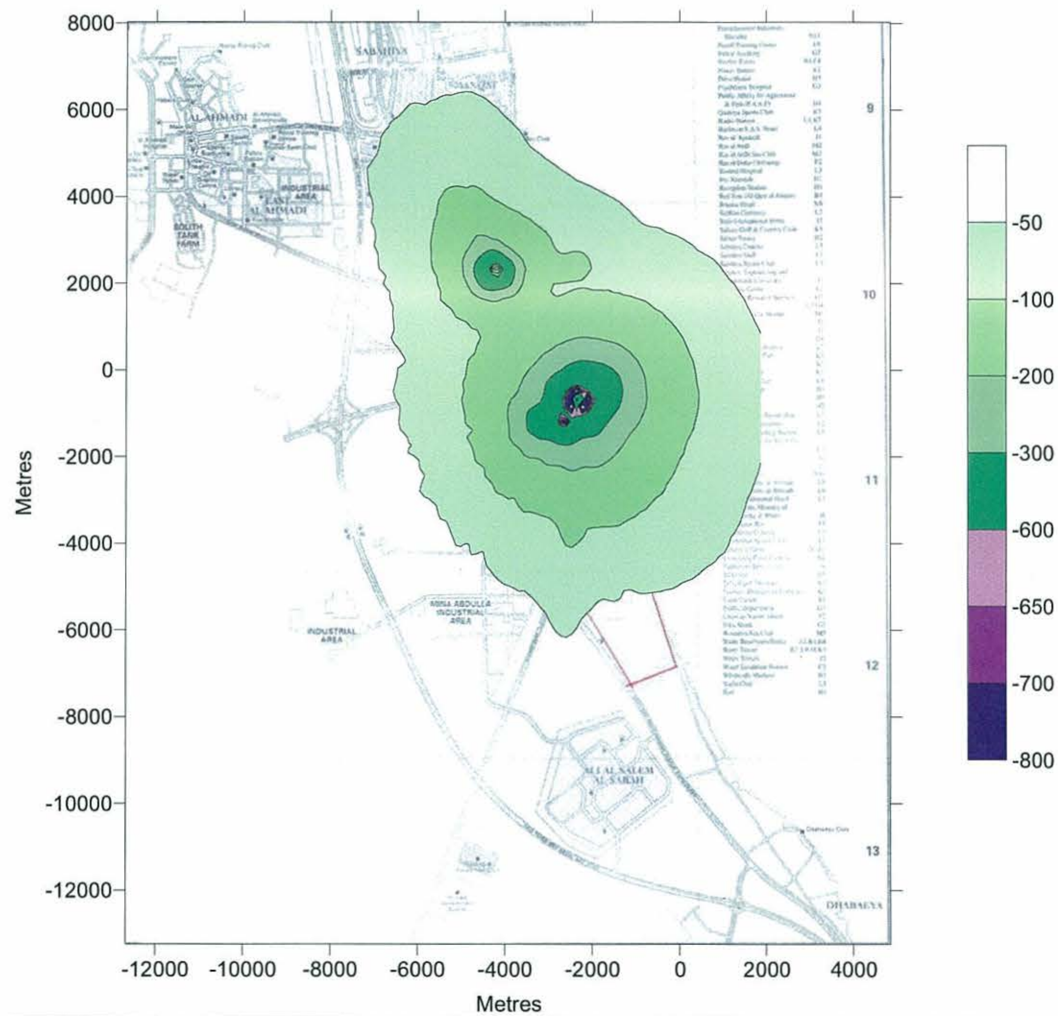
Figure 9.30: SO_2 99.7%ile 1-hour average (Combined – Base Case) – Maintenance 1



All concentrations are given in $\mu g/m^3$.

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Maintenance 2: Shutdown of CFP Block

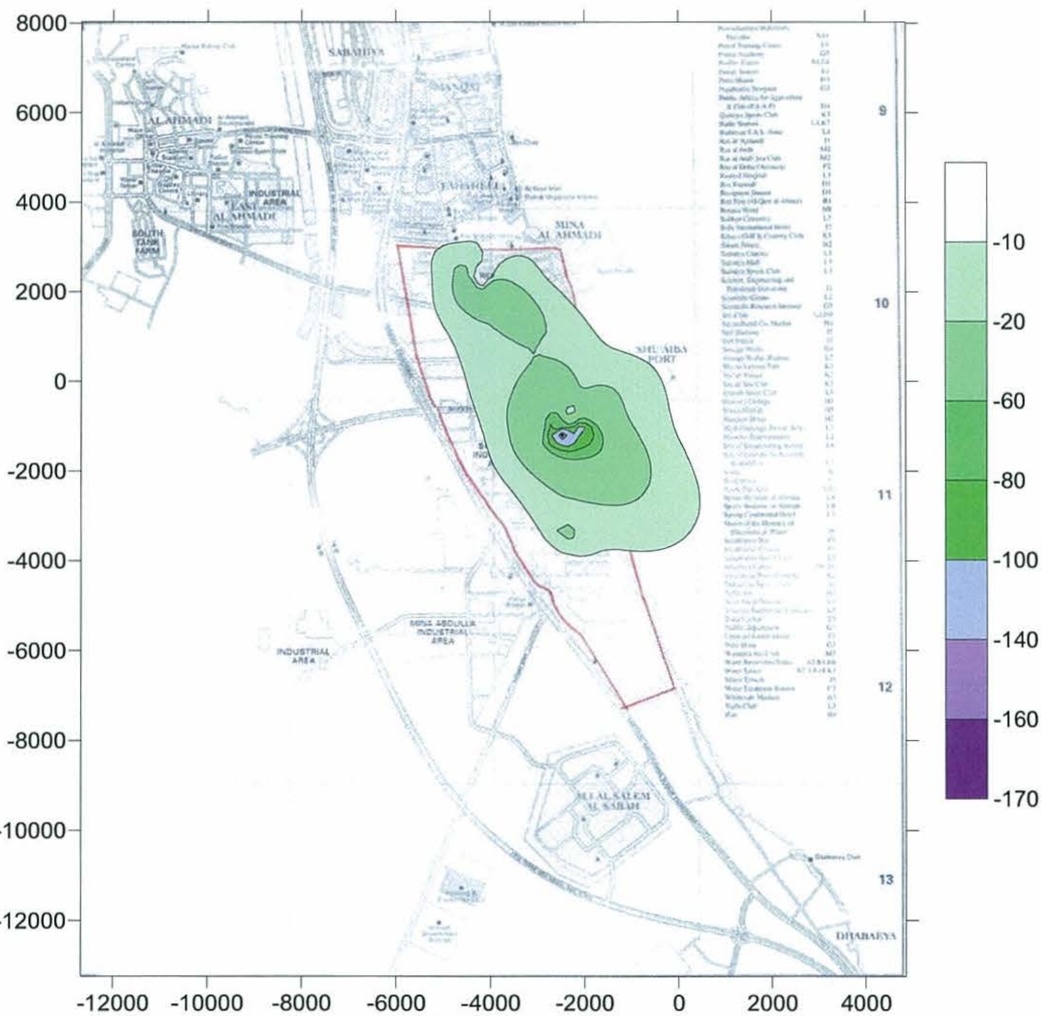
During the CFP block shutdown, the specific fired equipment items that would be shutdown are listed in Table 9.14 (eleven new units in MAA.)

The long term (annual average) and short term (99.7%ile 1 hour average) SO_2 ground level concentration contours results are presented in Figure 9.31 and Figure 9.32.

It can be seen that the resulting ground level concentration contour plots for sulphur dioxide are very similar to the Normal Base Case contour plots. Hence it is expected that post-CFP air quality would generally improve in the area.

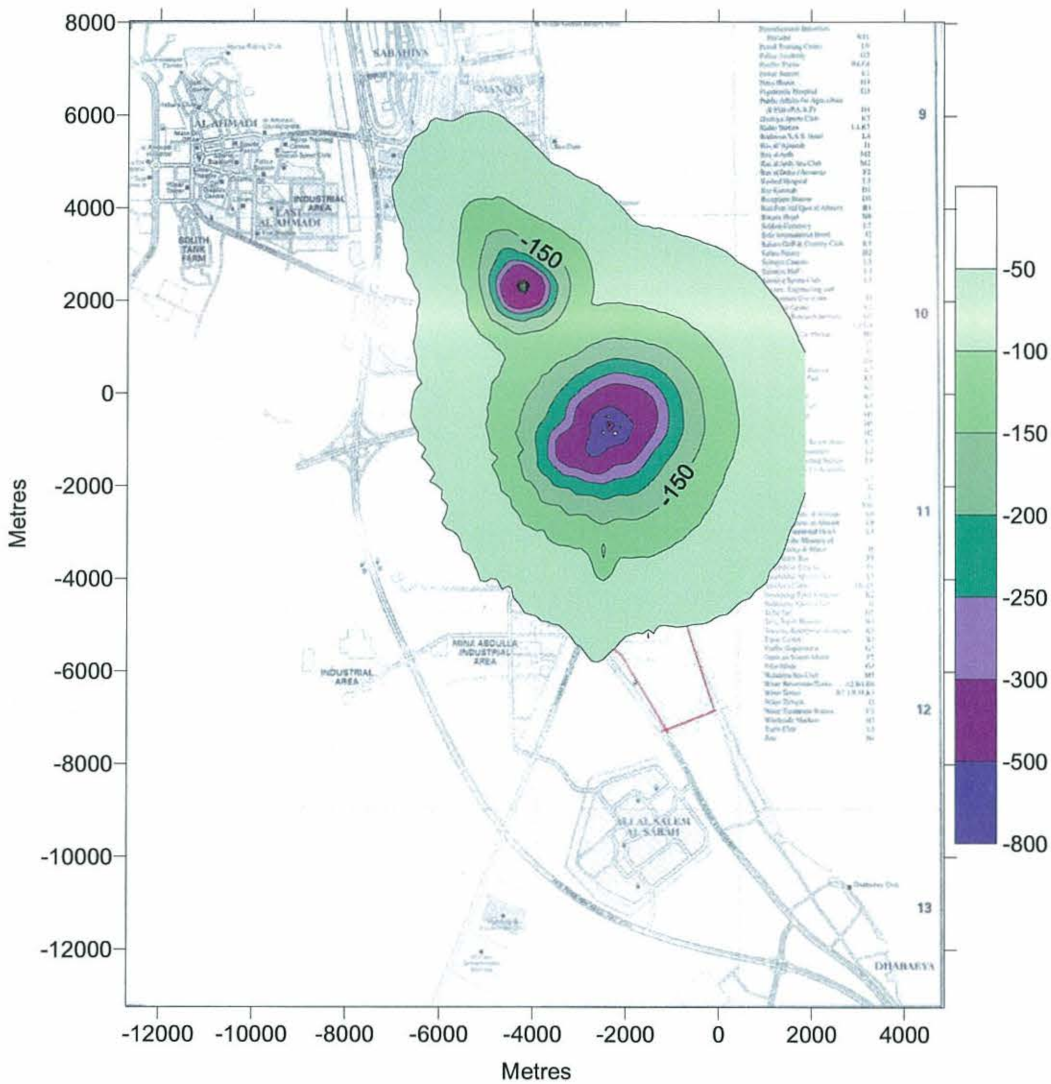
In conclusion, during CFP block maintenance, the SO_2 concentrations currently are within the K-EPA / MOO air quality criteria.

Figure 9.31: SO_2 Annual average (Combined – Base Case) – Maintenance 2



All concentrations are given in $\mu g/m^3$.

Figure 9.32: SO_2 99.7%ile 1- hour Average (Combined – Base Case) – Maintenance 2



All concentrations are given in $\mu g/m^3$.

9.5 Monitoring

The CFP's EMS will include a schedule for periodic monitoring (i.e., performance testing) of emissions from large fired equipment sources such as steam-generating boilers and process unit heaters. Stack sampling ports and fixed access platforms will be provided for all affected sources. A sampling protocol will be developed, in accordance with international methodologies, to include requirements for reporting and record keeping.

In addition, KNPC will periodically monitor the efficacy of vapour control equipment used to minimize loss of VOCs generated during loading operations at the port.

9.5.1 Continuous and Non-Continuous Emissions Monitoring (CEMS and Non-CEMS)

CFP 2020 will have both continuous and intermittent monitoring for the various air emission sources. These monitoring systems shall include area monitoring, fence line monitoring and in-stack monitoring of flue gases:

- **Point Source Monitoring:** stacks associated with large fired equipment sources that require monitoring will be equipped with sampling ports adequate to support stack gas performance testing.

- **Flare System Monitoring:** the flow rate for waste streams routed to each flare system shall be continuously monitored, displayed and recorded in the DCS control room.

- **Continuous and Periodic Emission Monitoring:** CEMS shall be installed for new dual-fired or oil-fired combustion sources with firing rates greater than 100 MMBTU/hr (~30 MW) and steam generators. It shall continuously measure and record NOx and SOx from each oil-fired heater/furnace/boiler; and Oxygen emissions for all furnace stacks where NOx and SOx are continuously measured. The CFP requirements for periodic and continuous emission monitoring shall be in accordance with KNPC's Procedure on Air Pollution Monitoring and Control.

- **Area/Ambient Monitoring:** CCTV Systems shall be used to monitor refinery operations such as flue gas stacks and pilots on flare systems. Thermocouples shall detect presence of a flare pilot flame. A Combustible Gas Detection System shall be in place to collect and summarize information regarding the ambient concentration of combustible gases such as hydrocarbons and hydrogen. Transmitters and alarms shall also be installed to detect flammable gas/vapours. A H_2S Gas Detection System will be used to monitor strategic areas where sour gas or sour liquids will be handled, processed or stored and a NH_3 Gas Detection System will be used to monitor strategic areas where ammonia may be present in either process or waste streams being handled, processed or stored. Appropriate equipment for monitoring the flow of process vent streams will be provided in the main header of flare systems. The requirement for AAQM at the fence line shall be reviewed vis-à-vis existing provisions and monitoring beyond the fence line shall be assessed subject to conditions specified by K-EPA for environmental approval of the project. A weather monitoring system shall continuously measure, record and read out various meteorological elements.

The monitoring methods used for all of the above shall be as specified by K-EPA otherwise they shall be in accordance with US EPA criteria. Data collection and management systems shall be consistent with those currently implemented for existing KNPC refineries.

9.5.2 Fugitive Emissions Management & LDAR

CFP will establish a programme for prevention, detection and control of fugitive emissions. A description of this programme is outlined below.

VOC emissions come mainly from fugitive emissions. Fugitive emissions are one of the largest sources of refinery hydrocarbon emissions. The aim in all refineries should be to prevent or minimise the release of VOCs. Control of fugitive emissions involve minimising leaks and spills through equipment changes, procedure changes and improved monitoring, good housekeeping and maintenance practices.

The only real option for process component fugitive release is the implementation of a permanent on – going Leak Detection and Repair (LDAR) programme. This consists of using a portable VOC detecting instrument to detect leaks during regularly scheduled inspections of valves, flanges and pump seals. Leaks are then repaired immediately or as scheduled for repair as quickly as possible. An LDAR programme could reduce fugitive emissions 40 to 60 percent, depending on the frequency of inspections.

A typical LDAR programme contains following elements:

- Type of measurement (e.g. detection limit of 500 ppm for valves and flanges, against the interface of the flange)
- Frequency (e.g. twice a year)
- Type of components to be checked (e.g. pumps, control valves, heat exchangers, connectors, flanges)
- Type of compound lines (e.g. exclude lines that contain liquids with a vapour pressure above 13kPa)
- What leaks should be repaired and how fast the action should be taken

The principle of fugitive loss is well known and their minimising has been the subject of much investigation and action, mainly led by operators subject to extremely tight regulations. Some techniques to consider are:

- An essential first step of any programme is to establish a fugitive release inventory for the refinery. This normally involves a combination of sampling, measurements, environmental, monitoring, dispersion modelling and estimates based on emission factors

- Identify all potential sources of VOC releases, by establishing population counts of equipment components in line with up to date P& I drawings for processes. This survey should cover gas, vapour and light liquid duties
- Quantifying of the VOC releases, initially as "baseline" estimates, and subsequently to more refined levels.
- A strategy to reduce VOC emissions: efficient seals and valves, good maintenance programmes, minimising number of flanged connections on pipelines and use of high specification joining materials, use of canned pumps or double seals on conventional pumps, use of end caps or plugs on open ended lines install maintenance drain – out system to eliminate open discharges.

9.5.3 KNPC Odour Management System

Odour management is a sensitive and challenging issue. Odours are difficult to measure and surrounding communities are sensitive receptors. As KNPC would like to remain a "Good Neighbour", a 5-year Odour Management System (OMS) has been built into the KNPC EMS with a common approach across all its sites, and is summarised in Figure 9.33. This is in line with the KNPC HSE standards. After 5 years, it will be managed as a regular activity.

Figure 9.33: Summary of KNPC OMS

OMS Mission

To be "odour-free"

OMS Vision

Be a role model among peers in running our business "odour-free" by adopting the best strategies for odour elimination.

Objectives:

1. Develop an OMS to eliminate odour from routine activities, eliminate odour from non-routing activities and minimise odor during emergencies.
2. Develop and action plan for the implementation of OMS

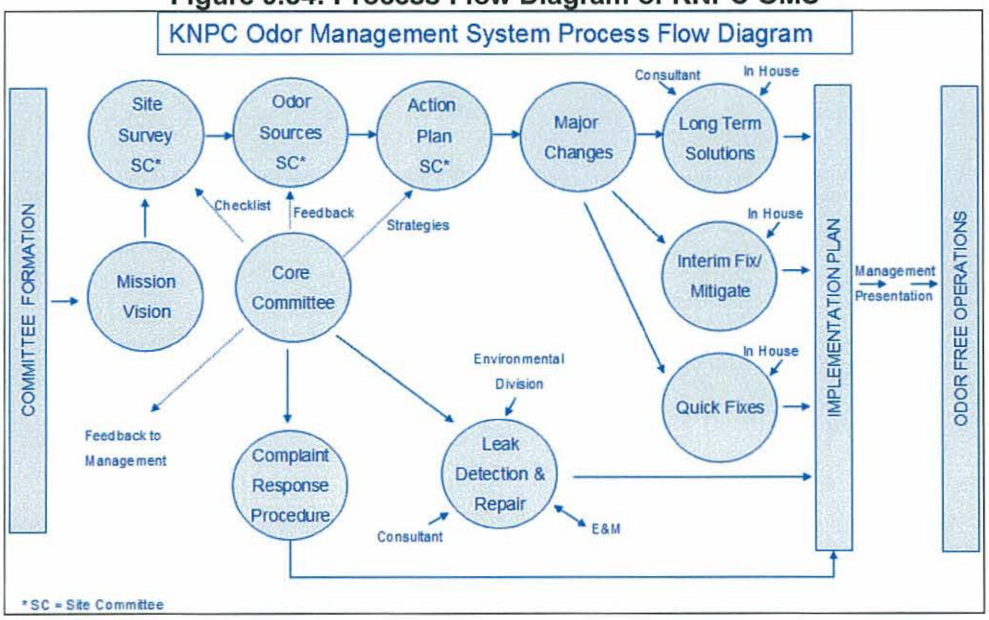
The KNPC OMS, is a proactive system that ensures continual improvement and, additionally:

- Improves overall environmental performance through fugitive emission monitoring, control and elimination.
- Enhances KNPC's ability to demonstrate a responsible environmental attitude which can dramatically improve its image thus foster a better relationship with the company's stake holders.
- Provides early detection of emissions from various sources thus reducing pollution incidents and associated expenses of recovery.
- Helps in early awareness of problems, which would offer the best opportunities for an efficient resolution.
- Reduces loses, improving the overall profit.

- Improves working environment and enhances Health and Safety standards resulting in an improved efficiency of the workforce.
- Creates a foundation for the next level of improvement.
- Demonstrates the organisations' proactive approach towards pollution prevention.
- Provides an effective structure for handling environmental complaints from the community as well as personnel working at KNPC.
- Exhibits a transparent image of the organisation by providing feedback to the complainant on KNPC's response.
- Enhances the quality of life outside, as well as inside KNPC by minimising the odour nuisance.
- Provides a structured approach for considering and addressing potential odour sources early in the project.

A process flow diagram describing the KNPC OMS is shown in Figure 9.34, and is briefly summarised in the section that follows.

Figure 9.34: Process Flow Diagram of KNPC OMS



Core Committee

This committee was formed to give direction to the Program and to provide feedback to management. It is comprised of members from all KNPC sites.

Site Committee

This committee was formed to coordinate activities at each site. They perform odour surveys to detect, identify and quantify odours, as well as locate their source.

Leak Detection and Repair

This program is designed to routinely monitor equipment for leaks, and to fix any equipment found leaking. The leak detection part of the Program will be carried out by a contractor using Optical IR cameras supplied by KNPC for identifying

Hydrocarbon leaks. PID/FID meters will be used to measure the concentration at the point of leak. The contractor will use hand-held gas analysers and check pre-identified non-hydrocarbon components to identify non-hydrocarbon leaks. The leaks will be repaired through existing KNPC work processes.

Complaint Recording and Tracking System

The purpose of this system is to receive, log, react to stop their occurrence and track all environmental complaints (both internal and external) associated with all KNPC activities. The source of these complaints will be identified and integrated into the list of odour stressors.

Odour Control Measures

Proposed control measures were identified by the Site Committees in consultation with Process, Operations and E&M representatives. The Core Committee, in consultation with Chevron, selected the best common solutions. The solutions were classified as:

- Quick fixes (short term)
- Long term capital upgrades
- Work process/Practice improvements, Procedural changes, LDA

9.5.4 Monitoring Methodologies

KNPC's procedures include the following main elements:

- air pollution control equipment will be maintained / operated to K-EPA / MOO criteria;
- measurements will be gaseous samples (lab) analysis or by continuous monitoring;
- monitoring the various parameters will be according to K-EPA / MOO requirements.
- responsibilities under the air monitoring procedures are also specified.

Monitoring methods will be as specified by K-EPA / MOO, otherwise they will be in accordance with USEPA criteria per 40 CFR Part 50, 40 CFR Part 53 for ambient air quality and 40 CFR Part 60 for stack emissions. Monitoring sampling system equipment will be based on monitoring the following parameters:

- Oxygen: via paramagnetic sampling;
- CO and SOx: via infrared absorption;
- NOx : via chemi-luminescence or UV fluorescence;
- SOx: via infrared absorption / UV fluorescence;
- Hydrocarbons: via photo / flame ionization.

CO emissions are monitored indirectly by oxygen sensors provided for combustion sources such as boilers and incinerators. Reporting and recordkeeping requirements for the CFP will be consistent with those currently implemented at the three existing KNPC refineries.

9.5.5 Communications, Calibration and Testing

CEMS sets out a number of communication requirements including: local data acquisition system (DAS); hardcopy environmental reporting will not be acceptable. DAS will be capable of handling data from multiple CEMS units (about 20), appropriate alarms (specified) must be in place, plus the minimum features for Integrated DAS.

All sampling and monitoring equipment will be calibrated and validated, including daily auto-validation (e.g. on high and low calibration gas) and manual calibration by technician intervention. Both a 'Factory Acceptance Test' (FAT) procedure for testing via contractors' own instrumentation, and a 'Site Acceptance Test' (SAT) will be undertaken after equipment is installed. Training for the KNPC engineering, maintenance and HSE personnel will be provided at the manufacturer's facilities as necessary.

9.6 CO_2 Emissions from the CFP

9.6.1 Introduction

This section provides an estimate of the Carbon Dioxide (CO_2) emissions that will result from CFP, which are then compared against current KNPC refinery annual CO_2 emissions to examine if CO_2 emissions will increase or decrease overall as a result of the CFP.

CO_2 is a greenhouse gas, which contributes to the phenomena of global warming. Although CO_2 has a low greenhouse warming potential relative to other greenhouse gases (i.e. methane, nitrous oxide, hydrofluorocarbons), it is produced in far greater quantities by refining operations.

The CO_2 calculations relate only to activities associated with combustion of fossil fuels at the refineries and do not include:

- Process related emissions (assumed similar before and after CFP).
- CO_2 emissions related to transport.
- CO_2 emissions from electricity consumption.
- CO_2 emissions related to flaring (assumed similar before and after CFP).

As such, this study is indicative only and is not in accordance to EU emissions trading scheme methodology.

This section also discusses KNPC's CO_2 reduction strategy document, KPC Corporate HSE: Management of energy and resources (Document 18).

9.6.2 Approach

The approach was to calculate the amount of net CO_2 emissions post-CFP by:

- Adding the 2007 CO_2 emissions associated with current refinery operations (pre-CFP) to the CO_2 emissions due to new fired CFP process facilities;
- Subtracting the CO_2 emissions that will be associated with the fuel burning process units at MAA, MAB and SHU that will be decommissioned.

The conclusions assume that SHU Refinery, as well as some process units at MAA and MAB, are decommissioned in parallel with the commissioning of the new CFP process units.

9.6.3 CO2 Emission Data

KNPC and Fluor provided the following CO_2 emission data (data not verified by DNV):

Table 9.33: 2007 CO_2 Emissions for MAA, MAB and SHU

Refinery	Tonnes CO_2 /yr
MAA	4,714,602
MAB	2,325,956
SHU*	2,408,984

**Note SHU data was based on 11 months data and pro rated for 12 months*

Table 9.34: 2007 CO_2 Emissions for Decommissioned Units at MAA, MAB and SHU

Refinery	Units retired	Tonnes CO_2 /yr
MAA	CDU-03	216,624
	H-44-001	36,089
MAB	CDU-01	167,448
	RCD U-03	37,032
	H2 U-03	199,860
	H-16-101	14,916
SHU	All units	2,408,984
All units		3,080,953

Data was also provided for normal fired–duties of new CFP units at MAA and MAB (see Table 9.35 and Table 9.36), which are then converted into CO_2 emissions using appropriate factors, as described below.

9.6.4 Calculation of CO_2 Emissions for New CFP Process Units

All CFP fired equipment will burn refinery fuel gas with the exception of two utility steam boilers at MAB which will burn fuel oil. Normal fired–duties of these new CFP units at MAA & MAB are provided in Table 9.35 and Table 9.36.

To calculate CO_2 emissions, the normal fired duty of the process units is multiplied by an Emission Factor, which were sourced from:

- UK Department of Environment Food & Rural Affairs : *Guidelines to Defra's greenhouse gas (GHG) conversion factors for company reporting June 2007* (www.defra.gov.uk)
- US Department of Energy: *Units conversion, emissions factors, and other reference data (Nov 2004).*

Table 9.35: List of New CFP 2020 Fired Equipment Air Emission Point Sources at MAA

(List does not include diesel engine drivers for emergency generators & fire water pumps, as they are only used intermittently)					
MAA Refinery					
Unit Number	**Point Source Description[1]**	**Equipment Tag Number**	**Fuel Type**	**Fired Duty**	**Normal Fired Duty[1]**
				MMBtu/hr	(kW)
	PROCESS UNITS				
135	DCU-NHTU Fired Heater	135-F-0101	Gas	10.0	2929
136	DCU - 2 Coke Heaters (Common Stack)	136-F-0201A/B	Gas	255.1	74743
137	Deisopentanizer - DIP Reboiler Heater	137-F-0101	Gas	177.9	52124
141	ARDS Reactor Feed Furnace	141-F-0201	Gas	55.0	16114
141	ARDS Fractionation Feed Furnace	141-F-0401	Gas	75.9	22238
148	HPU Reforming Furnace	148-F-0301	Gas	464.2	136000
151/152	TGTU Tail Gas Incinerator	151-F-0132	Gas	22.4	6574
151/152	TGTU Tail Gas Incinerator	152-F-0132	Gas	22.4	6574
183	VRU Vacuum Charge Heater	183-F-0101	Gas	170.0	49809
186	FCC-NHTU HDS Reactor Heater	186-F-0201	Gas	16.0	4673
186	FCC-NHTU HDS Reactor Heater	186-F-0202	Gas	20.5	5994
25/26	NHT Charge Heater (revamp existing)	H25-101	Gas	29.0	8491
25/26	NHT Charge Heater (revamp existing)	H26-101	Gas	29.0	8491
	U&O UNITS				
129	Steam System Utility Boiler (data is per boiler; total of 3)	129-F-0201A	Gas	362.3	106152
129	Steam System Utility Boiler (data is per boiler; total of 3)	129-F-0201B	Gas	362.3	106152

(List does not include diesel engine drivers for emergency generators & fire water pumps, as they are only used intermittently)

MAA Refinery					
Unit Number	**Point Source Description[1]**	**Equipment Tag Number**	**Fuel Type**	**Fired Duty**	**Normal Fired Duty[1]**
				MMBtu/hr	(kW)
	PROCESS UNITS				
129	Steam System Utility Boiler (data is per boiler; total of 3)	129-F-0201C	Gas	362.3	106152
187	Coke Handling (No Fired Equipment)	---	---		0
	NEW FEED UPDATE PROCESS UNITS				0
107	Isomerization	107-F-0101	Gas	57.8	16943
107	Isomerization	107-F-0102	Gas	259.7	76095
144	GOD	144-F-0101	Gas	38.0	11133
	TOTAL			**2789.8**	**817392**

[1] Conversion 1kW/mmBTU/h 0.003413

Table 9.36: List of New CFP 2020 Fired Equipment Air Emission Point Sources at MAB

Unit Number	Point Source Description[1]	Equipment Tag Number	Fuel Type	Fired Duty	Normal Fired Duty[1]
(List does not include diesel engine drivers for emergency generators & fire water pumps,as they are only used intermittently)					
MAB Refinery					
				MMBtu/hr	(kW)
	PROCESS UNITS				
111	Crude Distillation - 2 Heaters (Common Stack)	111-F-0101A/B	Gas	467.6	137005
112	ARDS Reactor Feed Furnace Train 1	112-F-0101	Gas	68.6	20099
112	ARDS Reactor Feed Furnace Train 2	112-F-0201	Gas	68.6	20099
112	ARDS Atmospheric Fractionator Feed Furnace	112-F-0401	Gas	160.5	47026
212	ARDS Reactor Feed Furnace	212-F-0101	Gas	68.6	20099
212	ARDS Atmospheric Fractionator Feed Furnace	212-F-0401	Gas	80.3	23527
114	Hydrocracker 1st Stage Gas Heater	114-F-0101	Gas	51.3	15030
114	Hydrocracker 2nd Stage Gas Heater	114-F-0102	Gas	69.7	20421
114	Hydrocracker Product Fractionator Feed Furnace	114-F-0103	Gas	304.1	89100
115	KHT Reactor Feed Furnace	115-F-0101	Gas	16.4	4805
116	DHT Reactor Feed Furnace	116-F-0101	Gas	93.9	27521
117	NHT Reactor Feed Furnace	117-F-0101	Gas	6.1	1787
118	H2 Plant Tubular Reformer Furnace (Train 1)	118-F-0101	Gas	1335.0	391151
118	H2 Plant Tubular Reformer Furnace (Train 2)	118-F-0201	Gas	1335.0	391151
123	SRU-TGTU Tail Gas Incinerator	123-F-0132	Gas	48.9	14327
123	SRU-TGTU Tail Gas Incinerator	123-F-0232	Gas	48.9	14327
123	SRU-TGTU Tail Gas Incinerator	123-F-0332	Gas	48.9	14327
127	CCR Reactor Feed Furnace (common stack)	127-F-0101/0102/0103/0104	Gas	218.1	63902

(List does not include diesel engine drivers for emergency generators & fire water pumps,as they are only used intermittently)					
MAB Refinery					
Unit Number	**Point Source Description[1]**	**Equipment Tag Number**	**Fuel Type**	**Fired Duty**	**Normal Fired Duty[1]**
				MMBtu/hr	(kW)
	PROCESS UNITS				
127	CCR Stabilizer Reboiler	127-F-015	Gas	18.2	5332
213	VRU Vacuum Charge Heater	213-F-0101	Gas	134.2	39320
11	CDU Fired Heater (existing)	H-11-101	Dual (Gas)	391.0	114562
			Dual (Liquid)		0
	U&O UNITS				
131	Steam System Utility Boiler (data is per boiler; total of 6)	131-F-0201A	Dual (Gas)	190.9	55923
			Dual (liquid)		0
131	Steam System Utility Boiler	131-F-0201B	Dual (Gas)	190.9	55923
131	Steam System Utility Boiler	131-F-0201C	Dual (Gas)	190.9	55923
131	Steam System Utility Boiler	131-F-0201D	Dual (Gas)	190.9	55923
131	Steam System Utility Boiler	131-F-0201E	Dual (Gas)	190.9	55923
131	Steam System Utility Boiler	131-F-0201F	Dual (Gas)	190.9	55923
156	WWT Oily Sludge Incinerator	156-A-0209-F01	Gas	8.9	2607
	NEW FEED UPDATE PROCESS UNITS				
214	Hydrocracker - 3 Heaters Combined (Common Stack)	214-F-0101/0102/0103	Gas	324.2	94989
216	DHT Reactor Feed Furnace	216-F-0101	Gas	93.9	27521
118	H2 Plant Tubular Reformer Furnace (Train 3)	118-F-0301	Gas	1335.0	391151
	TOTAL			**7941.2**	**2326738**

[1] *Conversion 1kW/mmBTU/h 0.003413*

Using data from Table 9.35 and Table 9.36, Table 9.37 provides the calculated CO_2 emissions for the new CFP project using UK Government guidelines.

Table 9.37: Conversion of CFP Fired Equipment Duty to CO_2 Emissions

				Guidelines to Defra's GHG conversion factors for company reporting		
				DEFRA		
				Natural Gas	Fuel Oil	
				kgCO2/kWh		**tonnesCO2/kg CO2h**
				Gross CV	Gross CV	
				0.185	0.267	1.00E-03
				KgCO2h		Tonnes Co2 /h
MAA	Refinery fuel gas	MMBtu/hr	2,790			
		kW	817,392	151,218		**151**
MAA : Total tonnes CO2/yr						**1,324,645**
MAB	Refinery fuel gas	MMBtu/hr	7,941			
		kW	2,326,738	430,447		**430**
MAB: Total tonnes CO2/yr						**3,770,654**

Note: When using data from supplied by US Department of Energy, emissions only vary by approximately 2%.
CV = Calorific Value

The following assumptions were made when estimating CO_2 emissions:

- When using reference data from DEFRA, the gross calorific value was used as advised by guidelines.
- Emission factor data for refinery fuel gas (20 – 50% hydrogen) was calculated by applying the natural gas emission factor multiplied by a factor of 1.07% (this is equivalent to Exxon refining group factor for refinery fuel gas)
- CO_2 emissions were calculated based on plant running 24 hrs for 365 days per annum.

9.6.5 Conclusions

Table 9.38 summarises the post-CFP CO_2 emissions provided SHU Refinery is decommissioned. It can be seen that there will be an estimated 18% increase in CO_2 emissions as a result of commissioning the CFP, which is a negative impact, although the decommissioned units at SHU, MAA & MAB offset approximately 60% of the new CFP facilities CO_2 emissions.

Table 9.38: Summary of CO_2 Emissions Pre & Post-CFP

	2007 Annual CO2 emissions	Annual CO2 emissions for the Retired Units post CFP			Annual CO2 emissions from CFP		Total annual CO2 emissions post CFP	
	tonnes/yr	Units	tonnes/mth	tonnes/yr	tonnes/yr	tonnes/yr		
					Defra	US Dept of energy	Defra	US Dept of energy
MAA	4,714,602	CDU-03	18,052	216,624	1,324,645	1,290,179		
		H-44-001	3,007	36,089				
MAB	2,325,956	CDU-01	13,954	167,448	3,770,654	3,672,544		
		RCD U-02	3,086	37,032				
		H2 U-03	16,655	199,860				
		H-16-101	1,243	14,916				
SHU	2,408,984	SHU		2,408,984				
Total	**9,449,542**			**3,080,953**	**5,095,299**	**4,962,723**	11,463,888	11,331,312
Increase in CO2 emissions							**18%**	**17%**

There will be opportunities for reducing CO_2 emissions as KNPC has outlined their energy conservation strategy to help preserve non-renewable resources for future generations in the KPC Corporate HSE: Management of Energy & Resources (Document 18).

KNPC has a policy in place to ensure all energy will be managed to best engineering environmental principles and within regulatory requirements (including international requirements) at all times. It commits to institute a written energy efficiency programme wherever energy is generated with clear objectives overseen by a competent person managing this programme. To ensure the programme is effective, audits will be conducted and adequate training of staff will be conducted. This will be part of the Environmental Management System (EMS) ISO14001.

9.7 Conclusions

- Air quality in the vicinity of the existing KNPC refineries generally improves as a result of the Clean Fuels Project:
- On commissioning the CFP, KNPC will decommission all significant air emission point sources at the SHU Refinery (as well as some units at MAA and MAB refineries), many of which have large emission rates. This will help reduce the pollutants emitted to atmosphere, hence improving the air quality in the area, because the new CFP sources that will be commissioned will emit significantly less than the decommissioned units.
- Overall, particularly for the "normal" CFP operating scenario, there will be improvements in the air quality for the vast majority of the monitoring point locations that currently do not meet criteria (i.e. where background data currently indicate that criteria are exceeded).
- This is mainly due to the fact that pollutant emission load from sources to be decommissioned far exceed the emissions associated with new CFP sources. For example, the total decommissioned source emissions for NO_x and SO_2 are approximately 211 g/s and 510 g/s, whereas for "normal" operation of the new CFP sources, the corresponding total NO_x and SO_2 emissions will be 124 g/s and 16 g/s respectively. Hence the resulting significant improvement.
- After the completion of CFP, the majority of long and short term NO_2 and SO_2 concentrations at the monitoring point locations are reduced for the "normal" emissions case. The TSP concentrations improve at all the monitoring point locations.
- For the "maximum" emission case, the CFP project results in a general overall improvement for both the long and short term concentrations of NO_2 and SO_2 at the various monitoring points as compared to baseline data. It should be noted though that in a number of monitoring point locations the long and short term NO_2 and SO_2 concentrations have increased after the completion of the CFP, but all comply with the applicable K-EPA / MOO criteria.
- There is only one case where, whilst exceeding the K-EPA / MOO relevant criteria, the pollutant concentration has been increased at a monitoring point (for the "maximum" case). This relates to the long term SO_2 concentration at location A24 (coastal area adjacent to MAB refinery), where the actual increase to the background long term concentration is around 2 $\mu g/m^3$.
- The CFP will increase KNPC's CO_2 emissions as a result of commissioning the CFP. Note that the decommissioned units at SHU, MAA & MAB offset approximately 60% of the new CFP facilities CO_2 emissions.
- CFP emissions during upset SRU emergency conditions (SRU Upset Scenarios 1 & 2) satisfy the relevant criteria.
- For the two maintenance scenarios (shutdown of RMP and CFP blocks), the resulting ambient air quality SO_2 concentrations will generally improve air quality compared against current conditions. However, it should be noted that during these shutdown maintenance events, sweet fuel gas will not be available. Instead, fired equipment in MAA Unit 107 and MAA Unit 137 will temporarily consume imported fuel gas that exceeds the H_2S limits specified in K-EPA Appendix 20 until maintenance work to facilities within the RMP block (for increased SO_2 emissions from Unit 107) and CFP block (for increased SO_2 emissions from Unit 137) is completed.

- Fugitive emissions on site from the tank farms areas satisfy relevant K-EPA criteria, after dispersion of the emissions is factored in. It should be noted that the total VOC emissions from the tanks are estimated to only represent approximately 50% of the total VOC emissions from the refineries, although other VOC fugitive emissions (process plant emissions) will not necessarily take place in the same physical area as the tanks.

  It may also be appropriate to compare the long term VOC modeling results (i.e. annual) against relevant criteria (such as EU criteria as there is no relevant K-EPA / MOO criteria), because the fugitive emissions from tanks are essentially averages over long periods of time (e.g. annually, monthly). The long term annual EU criterion for benzene is $5\mu g/m^3$, and this is exceeded by the KNPC emissions, though it should be noted that:
  - Benzene would only constitute a very small part of the overall VOC emissions.
  - The USEPA IRIS Reference Concentration (RfC) of 30 $\mu g/m^3$ (the concentration at which a lifetime's exposure is expected to have no adverse effect) is met by KNPC refinery emissions, although the RfC concentration is an estimate with significant uncertainty.
- Although, air quality in the study area improves as a result of the CFP, air quality criteria are still breached in some areas for some parameters.
- No conclusion can be drawn on the effect that the CFP has on the ambient H_2S concentrations, as no information was available for the decommissioned sources contribution related to this pollutant. Only information for new H_2S source emissions were included in the modelling conducted, and the resulting impact of these H_2S emissions from the new CFP sources is small (i.e. they do not significantly affect the ambient air quality). Therefore, any decommissioned units which has significant hydrogen sulphide emissions will improve the air quality in the refineries and the surrounding area.

- *Emergency Flare modelling*: The initial results for the emergency flaring scenarios indicate that the occupational exposure standards for SO_2 are exceeded, both within and beyond the refinery boundary, for the new acid gas flare at MAB (Unit 146). All other cases satisfy the occupational exposure standard for SO_2.

  Despite the fact that the occupational exposure criteria for sulphur dioxide are satisfied (with the exception of the new acid gas flare at MAB, Unit 146), some consideration has to be given for the resulting ground level pollutant concentrations beyond the fence-line of the refineries.

  In the absence of any guidelines or criteria from K-EPA/MOO for this type of emergency event beyond the refinery fence-lines, the CFP compared maximum ground level concentrations against more stringent US air quality criterion.

  Maximum ground level sulphur dioxide concentrations beyond the refinery fence-lines will exceed (for the flares associated with Units 162, 167, 146, 149 HP HC and the Total Power Failure Case based on the current design flare load and stack height) the US AEGL-2 (Acute Exposure Guideline Levels) criterion for sulphur dioxide.

  The acid gas flare at MAB (Unit 146) will also exceed the US ERPG-2 (US Emergency Response Planning Guidelines) criterion for sulphur dioxide.

As a result, sensitivity analysis was conducted with increased flare heights. This indicated that:

- The maximum ground level concentration of sulphur dioxide for all flare emission scenarios, including the TPF case, now meet the OEL criterion.
- The maximum ground level concentration of sulphur dioxide for all flare emission scenarios, including the TPF case, now meet the ERPG-2 criterion.
- Flare emissions Units 162 and 149 HP HC satisfy the stricter AEGL-2 criterion for sulphur dioxide.
- For the acid gas flares at MAA (Unit 167) and MAB (Unit 146), the AEGL-2 criterion for sulphur dioxide will be exceeded beyond the refineries fence-line, even at the revised height of 141 m.
- The revised combined TPF case, when accounting for the different stack heights for the revised heights of flares at MAA and MAB, improves from the base case, with the resulting sulphur dioxide ground level concentration still exceeding the AEGL-2 criterion. Unit 62 is the main contributor of sulphur dioxide emissions to the TPF case.

The key outcome from the sensitivity analysis is that further work should be conducted in order to investigate the peak ground level sulphur dioxide concentrations from Units 146, 167 and 62 (associated with the TPF case only). The peak concentration results for these units currently exceed the AEGL-2 criterion for sulphur dioxide beyond the refineries boundary.

Preliminary sensitivity analysis on the aforementioned flare units indicates that with the emission rate of sulphur dioxide halved, the resulting peak ground level concentrations will reduce proportionally. This would result in MAA Unit 167 Case 2 and the TPF case meeting the AEGL-2 criterion. MAB Unit 146 Case 2 would still not meet the AEGL-2 criterion. In order for this case to meet the AEGL-2 criterion, the emission rate of sulphur dioxide should be reduced to around 35-40% of its current value.

Consequently, KNPC will implement design changes during the EPC phase to reduce the relief loads for the flare systems which have the highest potential impact on the receptors located outside the refinery boundaries.

Note that the CFP flare systems have been modelled conservatively, as it has been assumed that:

- Emissions will be steady-state, whereas in reality releases associated with emergency flaring are anticipated to last for around 15 minutes to 1 hour.
- Based on operating experience from the KNPC refineries, it is unlikely that all flares will be emitting under emergency at the same time at both the MAA and MAB refineries (as modelled for the Total Power Failure scenario).
- It is noted that the beach houses located to the south-east of MAB refinery may not be occupied on a continuous, year-round basis.

9.8 Recommendations

It is recommended that:

- KNPC implement design changes during the EPC phase in order to reduce the relief loads to the flare systems, particularly for the flare systems that have the highest potential impact on sensitive receptors outside the refinery boundaries (Units 146, 167 and 62. Note that Unit 62 is associated with the Total Power Failure case).

- More detailed air dispersion modelling of the emergency flare scenarios should then be conducted during the detailed design / EPC stages of the project, to verify compliance with applicable criteria.

- Currently, the MIPP provides procedures for responding to gas release incidents. These should be expanded to include details for major emergency flaring events, and appropriate actions defined (e.g. warning residents).

- The CFP clearly improves air quality in the study area on a day-to-day basis, although exceedences for some parameters are still observed. It is recommended that scope for additional air quality improvements at the existing refineries be examined under KNPC's ongoing commitment to continuously improve environmental performance.

- It is important that a strict Leak Detection and Repair (LDAR) programme is implemented and enforced onsite to control VOC emissions. The new CFP facilities will be incorporated in the existing refineries LDAR programme.

- The Environmental Management System for the Clean Fuels Project should include a continuous performance improvement process for evaluating and maintaining the efficacy of emissions control equipment, and energy efficiency. The CFP facilities will be incorporated in the existing refineries' EMS.

10.0 Waste

10.1 CFP Waste Management

The CFP will generate a variety of solid wastes that are both hazardous and non-hazardous. All solid waste shall be termed either hazardous or non-hazardous in accordance with K-EPA criteria depending on its nature and/or the presence of contaminants.

As defined by Article No. 19 of the K-EPA regulations, hazardous wastes are *"any wastes posing potential direct hazards to man or animal's health or the environment in general, resulting from industrial, commercial and agricultural activities and from the household wastes, which are identifiable by any of the discipliners stated in Appendix No. 11-1 and classified in Appendix No. 11-2 hereof and, thus, require carrying out the toxicity tests, analyzing the waste filtrate to check the permissible limits stated in Appendix No. 11-3 hereof"*. Hazardous wastes may generally include any solid, semi-solid, liquid or contained gaseous waste, or combination of such wastes, which may because of its quantity, concentration, physical or chemical characteristics, pose a hazard or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed. These wastes include chemical wastes identified as discarded commercial chemical products, off-specification products/chemicals, container residues and spill residues."

Kuwait is a signatory to and has ratified the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes. This Convention imposes a number of obligations upon the signatory parties including appropriate measures to:

a. Ensure that the generation of hazardous wastes and other wastes within it are reduced to a minimum, taking into account social, technological and economic aspects;
b. Ensure the availability of adequate disposal facilities, for the environmentally sound management of hazardous wastes and other wastes, that shall be located, to the extent possible, within it, whatever the place of their disposal;
c. Ensure that persons involved in the management of hazardous wastes or other wastes within it take such steps as are necessary to prevent pollution due to hazardous wastes and other wastes arising from such management and, if such pollution occurs, to minimize the consequences thereof for human health and the environment.

K-EPA has adopted the definitions and characteristics for hazardous wastes developed under this convention. As such, the classification of hazardous characteristics for wastes generated by the CFP will be performed in accordance with the UN Class and Code as provided per the Basel Convention (refer to K-EPA Appendix No. 11-1). These hazardous characteristics are as follows:

- Explosive Substances;
- Flammable Liquids;
- Flammable Solid Substances;
- Substances or Wastes Liable to Spontaneous Combustion;
- Substances or Wastes Emitting Inflammable Gases when Contacting Water;
- Oxidizing Substances;
- Organic Peroxides;
- Poisonous Substances (acute);

- Infectious Substances;
- Corrosive Substances;
- Liberation of Toxic Gases in Contact with Air or Water;
- Toxic (delayed or chronic);
- Ecotoxic;
- Substances, which are capable, by any means, after disposal, of yielding another material, e.g. leachate, which possesses any of the characteristics listed above.

Among the categories of waste streams to be controlled under Annex III of the Basel Convention (K-EPA Appendix No. 11-2) which are expected to be generated by the CFP are:

- Category Y6 – Wastes from the production, formulation and use of organic solvents.
- Category Y9 – Waste oil / water, hydrocarbons / water mixtures, emulsions.
- Category Y11 – Waste tarry residues arising from refining, distillation and any pyrolytic treatment.
- Category Y12 – Wastes resulting from the production, formulation and use of inks, polish, colouring substances, paints lacquers and varnish.
- Category Y13 – Wastes resulting from the production, formulation and use of resins, plasticizers, glues and adhesive substances.

Other categories of wastes include non-hazardous industrial waste, municipal waste and inert waste.

- Non-hazardous industrial wastes include solid, liquid and semi-liquid wastes.
- Municipal wastes include garbage, refuse, food waste, office waste etc.
- Inert wastes are those wastes which are not biologically or chemically active in the natural environment, such as glass, concrete, brick, broken clay etc.

10.2 Waste Management Procedures

The management of both non-hazardous and hazardous liquid or solid wastes on site will be undertaken using the existing KNPC Procedure for Solid Waste Management (SHE-ENVP-03-006). The procedure ensures that solid wastes generated from all KNPC sites are managed in a systematic, controllable and accountable manner in order to reduce associated environmental risks to an acceptable level. The procedure also ensures compliance with applicable K-EPA requirements as well as international regulations and guidelines. The procedure involves the following:

10.2.1 Waste Segregation

- Different types of wastes shall be sorted and segregated for effective waste management;
- Incompatible waste shall be managed so as to minimise cross-reaction or chemical incompatibility. This prevents mixing of waste in a manner that will produce dangerous or harmful effects e.g. oxidizing acids must be kept away from organic acid and flammable and combustible materials'. A list of incompatible wastes is found in Annexure 2D of KNPC's Waste Management Procedures.

10.2.2 Screening and Identification of Hazard Characteristics

- Waste shall be categorized by using a common list of wastes generated at KNPC (Annexure 2E of SHE-ESHU-03-1406: Procedure for Solid Waste Management). This shall be done by the Environmental Division in consultation with the Waste Generating Department (WGD) and Technical Services Department;
- Wastes not listed in the common list will be characterised on the basis of chemical, physical and environmental characteristics as outlined in Annexure 3A (Categories of wastes to be controlled according to Basel Agreement), 3B (List of hazardous characteristics as per Basel Agreement), 3C (Toxicity Characteristic Leaching Procedure or TCLP test for hazardous characteristics) & 3D (limits allowed for hazardous pollutants concentration that leachate produce);
- If any waste is categorised in Annexure 3A and exhibits any one of the characteristics mentioned in Annexure 3B, the waste will be categorised as "Hazardous Waste". If the waste does not fall in any category of Annexure 3A, the waste shall be declared as "Non-Hazardous Waste";
- As part of the screening process, the waste needs to undergo TCLP testing and if any of the parameters stated in Annexure 3D is found in the waste in excess of the limit prescribed by K-EPA, the waste shall be declared as "Hazardous Waste".

10.2.3 Waste Profile Sheet

The Environment Division shall create a physical, chemical and environmental hazard profile for each type of waste in consultation with the WGD and Technical Services Department-Refineries/Technical Services Division-LM/Engineering Division-LM.

- The waste shall be allocated a unique 'WPS number', which refers to the Waste Profile Sheet for that given waste. The WPS Number of each waste is given in Annexure 2E The WPS number is extremely important as it:
    - Facilitates safe handling and disposal of wastes;
    - Acts as a data reference in case of emergencies such as spillage or uncontrolled release of the waste;
    - Is a requirement of K-EPA for off-site disposal of waste;
- Is a requirement of PAI in National Cleaning Company (NCC) Waste Transportation Manifest.

10.2.4 Labelling

- To facilitate safe identification of hazardous waste stored at the CFP for subsequent off-site management and disposal; standard waste identification and 'hazard warning' labels will be put on each hazardous waste container (e.g. U.S. Department of Transportation 'DOT' labels are already widely used in Kuwait);
- The Waste Handling Department (WHD) will be responsible for ensuring that comprehensive and accurate identification labelling is in place before any transfer of custody of the hazardous waste to any other receiver or storage facility;
- Each truckload of hazardous waste shall be 'safety placarded' (i.e. Transport Road Emergency 'TREM' card plus 'DOT' labelling or National Fire Protection Association 'NFPA' fire safety hazard warning labelling indicating basic material data and hazard properties) to ensure that emergency response crews arriving in the case of a road spillage or similar accident can be aware of immediate risks during response;
- If the hazardous waste is being transported onto public highways, it shall be required that TREM/DOT/NFPA road safety placard is used;

- Re-used containers shall be decontaminated and have previous labels and markings removed.

10.2.5 Temporary storage

- The storage of waste is only acceptable as an interim measure to permit time for the collection of sufficient volumes for cost effective transport to a recycler or disposal facility;
- Wastes will, where possible, be temporarily stored in original containers or in containers (sound, sealable and not damaged) that are designed to contain a specific waste (hazardous or non-hazardous):
- Bulk wastes will be placed in good quality steel or plastic drums which will be labelled. The container must be of the correct size for its volume, must have a 5cm gap for expansion, must always be closed and must be sealed when full;
- Containers will be protected from weather and physical damage in secure, paved and shaded areas with controlled access to trained persons only. The area shall be equipped with a communication facility, portable fire extinguishers, spill control and decontamination equipment, water at adequate volume and pressure and Personal Protective Equipment (PPE);
- Wastes shall be stored to prevent spills from entering the sewer system;
- Wastes shall be kept segregated and stored in a manner consistent with information on the label, on the MSDS, and prudent practices.

10.2.6 Waste Tracking

- An internal manifest (Annexure 5A) system will be implemented for all internal waste movement at the CFP such as oily sludge movement from all sites including MAB to Oily Sludge Handling & Treatment Facility and spent catalyst transfer to MAA catalyst yard from SHU/MAA etc;
- All wastes transported from the CFP for disposal, whether by flatbed vehicle containers (drums, bags, bottles, intermediate bulk container, gas cylinder, pallet load etc.) or in bulk (tipper trailer or dump truck for solids and semi-solids or vacuum tanker for liquids and sludge); shall be manifested.
    - Hazardous Waste: A Waste Transportation Manifest (WTM) will be completed and carried along with the waste for each vehicle load.
    - Non-Hazardous Waste: A single WTM may be completed for the entire load (several truck loads), if the entire load is being moved out on the same day. If necessary, transporters and their details may be endorsed in a separate sheet appended to the manifest. (Annexure 5B)
- The WTM will include adequate information of all wastes carried by the vehicle such as their hazard characteristics (hazardous or non-hazardous) chemical names and/or KNPC 'Waste Profile Numbers.
- The Environment Division shall supply blank manifest sets as needed and record the manifest number given to any department. WGD/WHD shall keep record of all manifests issued for environmental auditing.
- For recovery / re-use in close-loop system inside the refinery, the "Internal Waste Transportation Manifest System" needs to be followed e.g. reprocessing of slop oil etc. (single manifest for any number trip in a day).

10.2.7 Transportation, Treatment and Disposal

- Waste generated from the CFP should be recycled/re-used/recovered in the first instance.
- Once the waste is identified, characterised and labelled, it shall be disposed to the appropriate waste disposal site by waste transporters
- Transporters shall have their capabilities reviewed by KNPC and shall be forwarded to K-EPA for registration.
- All precautions should be taken and relevant safety procedures should be followed while handling hazardous wastes.
- WGD should promptly contact the Environment Division if any waste requires urgent management action or input to prevent environmental degradation.
- Controlled disposal of hazardous wastes shall take priority over the disposal of inert wastes to minimise exposure to hazard risks and maximise effectiveness of wastes management resources.
- The waste receiver shall acknowledge the WTM for all hazardous wastes. Copies must be forwarded to appropriate authorities.
- Pre-treatment shall be done by the Waste Receiver to render selected hazardous wastes into inert/stable and innocuous; prior to land filling.
- WHD shall ensure that the Waste Receiver acknowledges that all hazardous wastes have been received and will be disposed of in compliance with accepted environmental standards and K-EPA regulations. This acknowledgement shall be called as a Waste Disposal Ticket (WDT) and shall have a cross reference to each waste taken from KNPC.

10.2.8 Recording and Reporting

- In order to have an auditable waste management system, necessary records of documents shall be maintained by WHD & WGD for a minimum period of 3 years.

10.3 Solid Waste Management during Construction

Construction and modification of the CFP facilities will produce a variety of solid wastes. Bearing in mind that the number of construction staff (direct plus indirect at peak manpower) is approximately 36,000, waste quantities are expected to be significant.

However, it should be noted that any waste generated as a result of decommissioning activities during the construction phase of CFP is not covered as part of this EIA. Decommissioning waste will be discussed and evaluated in a separate document.

Wastes likely to be generated during construction of CFP are listed below:

- Spoil from excavation works for foundations
- Scrap steel and off-cuts, including weld mesh, conduit, pipe-work, nuts, bolts, concrete reinforcing rods
- Timber waste from formwork and shipping crates
- Concrete, plaster board and cement sheeting
- Insulation materials
- Plastics from conduit and pipe-work
- Paints & solvents
- Transformer oils

- Chemical Cleaning products and neutralised chemical cleaning solutions
- Spent lube oils
- Oily wastes from construction vehicles and oily/contaminated rags
- Miscellaneous wastes from a range of construction activities including general office waste, paper, food scraps, food containers and wrappings
- Packaging materials from equipment, material store and spare parts
- Sanitary waste (sanitary and liquid effluent is considered in Wastewater Management, Chapter 12).

During construction, management of solid waste in work areas and camps will be the responsibility of each EPC contractor. Each EPC contractor will manage wastes in accordance with a KNPC-approved Waste Management Plan (WMP) which will comply with the existing KNPC Procedure for Solid Waste Management (SHE-ESHU-03-1406).

Each EPC contractor will develop their WMP once more detailed information on construction waste is available. The WMP will describe how wastes will be managed during the construction, commissioning and start-up phases of the project, taking into account the existing waste infrastructure within KNPC. The WMP will also include the provision of waste skips in a central collection point within the EPC contractor's area and the marking of skip bays in order to segregate waste prior to removal from site. Waste containers will be periodically collected and disposed of in a manner consistent with the waste management system.

The WMP will require:

- The recycling and re-use of solid wastes wherever possible;
- All waste to be appropriately segregated;
- The temporary storage of waste to be carried out according to type (e.g. inert, non-hazardous and hazardous – ignitable, corrosive, reactive, toxic, radioactive, bio-hazardous, etc.);
- Wastes to be stored in suitable containers clearly marked according to contents. Hazardous wastes will be stored in a safe secure area where storage containers can be inspected for leaks or deterioration;
- Municipal waste to be collected and sent to either a local municipality for treatment or to the existing refinery treatment facility;
- Hazardous waste (such as oily wastes from vehicles) will be transported to an approved site;
- Adoption of the existing KNPC Waste manifest system for the transfer of waste materials; and is discussed below;
- Auditing of the EPC contractors is recommended. This should be conducted at regular intervals throughout construction, commissioning and start-up phases of the project by an independent consultant. This will ensure that that EPC contractors are in compliance with the WMP;
- Construction debris will be removed on a regular basis to prevent build-up and will be disposed of at the solid waste disposal site. Construction waste will not be mixed with domestic waste.

The generation of solid waste during construction is unavoidable. However, all wastes will be sorted, segregated and then screened for identification of hazardous characteristics, before they are moved offsite, to maximise re-use and recycling opportunities. An action plan for managing waste generated during CFP decommissioning activities should be developed by KNPC and submitted to K-EPA for review and approval prior to start of decommissioning activities.

A significant portion of construction materials can be recycled, for example:

- Wood Products will be recovered and reused
- Scrap steel and offcuts will be recycled
- Plastics will be recycled where practicable

Construction activities are unlikely to give rise to many hazardous wastes with the exception of oily wastes. All oily wastes will be stored in bunded tanks on impermeable flooring and will be disposed of in accordance with regulatory requirements using appropriately licensed waste disposal contractors. All temporary bunds will slope to sumps, which require suction cleaning (and have no bund drain down outlets) on a regular basis in order to maintain their effectiveness. Bunds will enclose all ancillary equipment (e.g. fill and draw off facilities, vent pipes, taps, valves, etc) and will be inspected on a regular basis.

10.4 Solid Waste Management during Operation

Both the new and modified CFP facilities will operate under the KNPC Procedure for Solid Waste Management (KNPC Procedure Number SHE-ESHU-03-1406) during operations.

The purpose of the waste management plan is to ensure that appropriate waste management practices are followed in accordance with relevant prevailing national laws, regulations, and requirements regarding the protection and preservation of the environment. In addition, the waste management plan will require that personnel working where waste is generated within the area of the CFP, periodically review operations and evaluate available methodologies for reducing or eliminating the CFP wastes.

Both onsite and offsite units and utilities provided by this project shall be designed to minimise the production of solid waste as required by Article No. 26 of the K-EPA regulations. Typically during refinery operation solid and semi-solid wastes will be generated from several various sources, including administration and support buildings as well as process units.

The solid wastes generated from above-mentioned sources include, but are not limited to:

- Spent catalysts/unusable catalysts
- Oily sludge and other hydrocarbons
- Coke fines
- Contaminated sulphur and other inorganic chemical waste
- Used resins
- Spent oil, lubricants and grease
- Waste activated carbons
- Filter media
- Contaminated soil
- Tyres from plant services and refinery workshops
- Batteries
- Scrap metals
- General packaging and containers
- General process waste;
- Electrical equipment
- Spilled and lost product
- Laboratory waste

- Food waste
- Fluorescent tubes
- Waste paper

The two tables below outline the amounts of the key process solid waste streams likely to be produced by each new and each revamped unit during CFP operation in each of the refineries, MAA and MAB. Both hazardous and non-hazardous solid waste will be generated; it can be seen that the bulk of solid wastes produced are spent catalyst generated at intervals, and these are generally hazardous waste. The CFP facilities at SHU are not expected to generate any hazardous wastes and the amount of non-hazardous solid waste is not expected to be significant.

Table 10.1 Preliminary Amounts of Process Hazardous and Non Hazardous Waste from New and Revamped CFP Units at MAA

Unit	Waste	Quantity	Hazardous Waste (Yes/No)	Hazardous Characteristics	Replacement Frequency	Disposal
25/26	Spent hydrotreating catalyst	47.1 MT	Yes	Ignitibility Toxicity	Every 4 years	Regeneration or hazardous waste landfill
46	None					
83	None					
86	None					
99	None					
107	Dry Slops	Variable	Yes	Flammable	Intermittent	Routed to Storage
	Wet Slops	Variable	Yes	Flammable	Intermittent	Routed to Storage
	Spent Catalyst	Unknown	Yes	Metals	6 years	Landfill and metals recovery
	Gas drier Mol Sieve	Unknown	No	n/a	3 years	Landfill
	Feed Drier Mol Sieve	Unknown	No	n/a	3 years	Landfill
	Methanation Catalyst	Unknown	Yes	Metals	3 years	Landfill and metals recovery
	Sulfur Absorption	Unknown	Yes	Metals	3 years	Landfill and metals recovery
	Sulfur Absorption	Unknown	Yes	Metals	3 years	Landfill and metals recovery
113	Miscellaneous construction waste	Variable	No	n/a	Continuous	Landfill
125	Wet Slops	Variable	Yes	Hydrocarbons	Intermittent	Routed to Storage
	Spent Catalyst	789kg	Yes	Metals	4 years	Landfill & Metals Recovery
	Spent Sulfur Absorbent	4240kg	No	n/a	6 months	Landfill
	Spent Chloride	41390kg	No	n/a	6 months	Landfill
129	Amine and Oxygen Scavenger	66.7m3/hr	Yes	Toxic	Intermittent	Cooling water return or AOC Sewer
135	Spent Catalyst	1668kg	Yes	Metals	5 years	Vendor Reclamation
	Spent Catalyst	1356kg	No	n/a	5 years	Landfill
	Spent Catalyst	16045kg	Yes	Metals	5 years	Vendor Reclamation
	Spent Catalyst	24700kg	Yes	Metals	5 years	Vendor Reclamation
	Sour Water	4.73 m^3/hr	No	n/a	Intermittent	To SWS
136	Sour Water	13330 kg/hr	Unknown at this stage.			
	Sour Water	120000kg				
	Light Slop	100 kg/hr				
137	Hydrocarbon	11.4m^3/h	Yes	Flammable	Intermittent	Routed to Storage (Wet Slops)
	Water & Hydrocarbon	22.7m^3/h	Yes	Flammable	Intermittent	Routed to Storage (Wet

Unit	Waste	Quantity	Hazardous Waste (Yes/No)	Hazardous Characteristics	Replacement Frequency	Disposal
						Slops)
138	Disulfide Separator Vent Gas	0.367 ft3/s			Continuous	To DIP Reboiler Heater
	Disulfide Oil with Wash Oil	~1gpm			Continuous	To DIP Flare Knockout Drum
	Spent Caustic	~3gpm			Daily batches	To spent Caustic Disposal System
	Extraction Spent Caustic				As required	To Spent Caustic Degassing Drum
	Steam Condensate	0.1gpm			Continuous	To WWT via Oily Process Water Sewer
	Sand from Sand Filter	256 ft3			Intermittent	Landfill
141	Spent Catalyst	1,004,233 kg	Yes	Metals	1 Per yr	Landfill & Metals recovery
	Fresh Catalyst fines	1,000 kg	Yes	Metals	1 Per yr	Landfill
	Hydrodrilling Water	650m^3	Yes	Dissolved Metals	1/year	Will not be treated with other refinery water
	Soda Ash Solution	Unknown	No	n/a	Intermittent	Unknown
144	Spent Catalyst and Grading Material		Yes	Metals	Every 30 months	Returned to manufacturer for metals recovery
	Filter Sludge	TBD				
146	Oily Water	23 m^3/h	Yes	Flammable	Intermittent	Routed to Storage (Slops Tanks)
148	Spent Catalyst	8,832 kg	Yes	Metals	Every 5 years	Landfill
	Spent Catalyst	41,984 kg	No	Metals	Every 5 years	Landfill
	Spent Catalyst	6,144 kg	Yes	Metals	Every 5 years	Landfill
	Spent Catalyst	7,744 kg	Yes	Metals	Every 5 years	Landfill
	Spent Catalyst	19,072 kg	Yes	Metals	Every 5 years	Vendor Reclamation
150	Spent Carbon	46 m3/yr	Yes	Toxic	Once Per Yr	Secure Landfill
	Filter Cartridge	4 Cartridges	Yes	Toxic	Once Per Yr	Secure Landfill
	Filter Cartridge	4 Cartridges	Yes	Toxic	Once Per Yr	Secure Landfill
	Filter Cartridge	1 Cartridge	Yes	Toxic	Once Per Yr	Secure Landfill
	Spent Amine	330m^3/yr	Yes	Toxic	Intermittent	As per std refinery practice
	Amine Carbon Filters	15m^3/yr	Yes	Toxic	Once Per Yr	As per std refinery practice
	Caustic Wash	N/A	Yes	Caustic	Intermittent	As per std refinery practice
	Chemical Cleaning	N/A	Yes	Toxic	Intermittent	As per std refinery practice

Unit	Waste	Quantity	Hazardous Waste (Yes/No)	Hazardous Characteristics	Replacement Frequency	Disposal
151 - 152	Spent Catalyst	23,500 kg	No	n/a	5 Yrs	Landfill
	Ceramic balls	9,500 kg	No	n/a	5 Yrs	Landfill
	Spent Catalyst	21,100 kg	No	n/a	5 Yrs	Landfill
	Ceramic balls	9,500 kg	No	n/a	5 Yrs	Landfill
	Spent Catalyst	15,000 kg	Yes	Toxic	5 Yrs	Vendor Reclamation
	Ceramic balls	8,400 kg	No	n/a	5 Yrs	Landfill
	Activated carbon	1,000 kg	No	n/a	2 Per yr	Landfill
	Filter Cartridge	Each	Yes	Toxic	2 Per yr	Secure Landfill
	Filter Cartridge	Each	Yes	Toxic	6 Per yr	Secure Landfill
	Filter Cartridge	Each	No	n/a	6 Per yr	Landfill
	Filter Cartridge	Each	Yes	Toxic	1 Per yr	Secure Landfill
153	Active Carbon	2.1 ft^3	No	n/a	3 yrs	Landfill
	Filter Sludge	TBD				
156	Stripped Sour Water	168 m^3/h	No			To process units WWT-163
162	Wet Slops	34 m^3/hr	No	n/a	Continuous	To wet slops system
163	Dry Slops	3,180 m^3	No	n/a	6,360 m3 Per Month	To Oil Drips System
	Spent Diesel, Dry Slops	3,180 m^3	No	n/a	6,360 m3 Per Month	To Oil Drips System
	Wet Slops	954 m^3	No	n/a	4,000 m3 Per Month	To Oil Drips System
166	None					
167	Sour Water	11 m^3/hr	No	n/a	Continuous	To Sour Water Treatment Unit
171	Activated Alumina	13,800 kg	No	n/a	3-5 years	Landfill
174	Slops	5.0 m^3/hr	Yes	Toxic	Intermittent	To Oil Drips System

Unit	Waste	Quantity	Hazardous Waste (Yes/No)	Hazardous Characteristics	Replacement Frequency	Disposal
175	Blowdown of Cooling Water	55,800 kg/h	No	n/a	Continuous	Flow to AOC
	Backwash of SSF	2,49,400 kg/h	No	n/a	Intermittent	Flow to AOC
	Spent Filter Sand	15.6 m^3	No	n/a	Once every 10 yrs	Landfill
	Spent Filter Gravel	15.6m^3	No	n/a	Once every 10 years	Landfill
176	Activated Carbon	1.0 m^3	No	n/a	3 yrs	Landfill
	Spent Polish Cation Resin	13.5 m^3	No	n/a	5 yrs	Landfill
	Spent polish Anion Resin	13.5 m^3	No	n/a	4 yrs	Landfill
	Spent Demin Cation Resin	20.0 m^3	No	n/a	5 yrs	Landfill
	Spent Demin Anion Resin	29.9 m^3	No	n/a	4 yrs	Landfill
	Spent Filter Anthracite	21.0 m^3	No	n/a	10 yrs	Landfill
	Spent Filter Sand	21.0 m^3	No	n/a	10 yrs	Landfill
	Spent Filter Gravel	5.4 m^3	No	n/a	10 yrs	Landfill
177	None					
178	Miscellaneous municipal waste	Variable	No	n/a	Continuous	Landfill
183	None					
186	Spent Catalyst	32 m^3	Yes	Metals	4 years	Vendor Reclamation
	Spent Catalyst	5 m^3	No	n/a	4 years	Landfill
	Spent Catalyst	115 m^3	Yes	Metals	4 years	Vendor Reclamation
187	None					
195	Stripped sour water	170 gpm	No	n/a	Continuous	To WWT Plant
283	None					

Table 10.2 Preliminary Amounts of Process Hazardous and Non Hazardous Waste from New and Revamped CFP Units at MAB

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
11	Coke Fines	Indeterminate	Yes	Metals	5 Years	Secure Landfill
	Sour Water	87gpm	Yes	Toxic	Intermittent	Sour Water Stripper
	Desalter Effluent	366 gpm	Yes	Toxic	Intermittent	Waste Water Treatment
	Dry Slops	1901 gpm	Yes	Flammable	Intermittent	Storage
	Wet Slops	127 gpm	Yes	Flammable	Intermittent	Storage
13	None					
50	None					
54	None					
111	Coke Fines	6,000 kg	Yes	Metals	6 Years	Secure Landfill
	Sour Water	51gpm	Yes	Toxic	Intermittent	Sour Water Stripper
	Desalter Effluent	176 gpm	Yes	Toxic	Intermittent	Waste Water Treatment
	Dry Slops	120 gpm	Yes	Flammable	Intermittent	Storage
	Wet Slops	20 gpm	Yes	Flammable	Intermittent	Storage
112	Spent Catalyst	1,005,782 kg	Yes	Metals	2/year	Landfill & Metals Recovery
	Fresh Catalyst Fines	1,000 kg	Yes	Metals	2/year	Landfill
	Hydrodrilling Water	650m^3 per batch	Yes	Dissolved Metals	2 years	Will not be treated with other refinery water
	Soda Ash Solution	Unknown	No	n/a	Intermittent	Unknown
113	None					
114	Spent Catalyst	39,500 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	378,500 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	906,000 kg	No	n/a	2 years	Landfill
	Broken Ceramic Balls	15,100 kg	No	n/a	2 years	Landfill
115	Spent Catalyst	4,367 kg	No	n/a	2.5 years	Landfill
	Spent Catalyst	2,708 kg	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	6,770 kg	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	56,284 kg	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	212,081 kg	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	29,928 kg	Yes	Metals	2.5 years	Vendor Reclamation
116	Spent Catalyst	590 m^3	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	142 m^3	Yes	Metals	2.5 years	Vendor Reclamation

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
	Ceramic Balls	23.8 m^3	No	n/a	2.5 years	Landfill
117	Spent Catalyst	2,673 kg	No	n/a	2 years	Landfill
	Spent Catalyst	2,986 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	26,493 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	16,310 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	1,361 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	43,222 kg	Yes	Metals	2 years	Vendor Reclamation
118	Spent Catalyst	60,544 kg	Yes	Metals	every 6 years	Vendor Reclamation
	Spent Absorber	263,168 kg	No	n/a	every 1 year	Landfill
	Spent Catalyst	41,344 kg	Yes	Metals	every 6 years	Vendor Reclamation
	Spent Catalyst	43,264 kg	Yes	Metals	every 6 years	Vendor Reclamation
	Spent Catalyst	19,840 kg	Yes	Metals	every 6 years	Vendor Reclamation
	Spent Catalyst	153,344 kg	Yes	Metals	every 6 years	Vendor Reclamation
119	Sour Water	6.9 m^3/hr	No	n/a	Continuous	Sour Water Header
	Mole Sieve Packing	To be completed by EPC contractor once PSA vendor selected.				
	PSA Adsorbant					
123	Spent Catalyst	51,000 kg	No	n/a	5 years	Landfill
	Ceramic balls	9,500 kg	No	n/a	5 years	Landfill
	Spent Catalyst	47,000 kg	No	n/a	5 years	Landfill
	Ceramic balls	9,500 kg	No	n/a	5 years	Landfill
	Spent Catalyst	31,400 kg	Yes	Metals	5 years	Vendor Reclamation
	Ceramic balls	19,600 kg	No	n/a	5 years	Landfill
	Activated Carbon	2,120 kg	No	n/a	6 mo.	Landfill
	Filter cartridge	1	Yes	Metals	6 mo.	Secure Landfill
	Filter cartridge	1	Yes	Metals	2 mo.	Secure Landfill
	Filter cartridge	1	No	n/a	2 mo.	Landfill
	Filter cartridge	1	Yes	Metals	1 year	Secure Landfill
125	Spent Carbon	46 m^3	Yes	Toxic	1 year	Secure Landfill
	Filter Cartridges	2	Yes	Toxic	1 year	Secure Landfill
	Filter Cartridges	2	Yes	Toxic	1 year	Secure Landfill
	Filter Cartridges	1	Yes	Toxic	1 year	Secure Landfill
	Spent Amine	890 m^3/yr	Yes	Toxic	1 year	As per std refinery practice
	Amine Carbon filters	25 m^3/yr	Yes	Toxic	1 year	As per std refinery practice
	Caustic Wash	N/A	Yes	Caustic	Intermittent	As per std refinery practice

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
	Chemical Cleaning	N/A	Yes	Toxic	Intermittent	As per std refinery practice
126	Stripped Sour Water	214 m^3/hr	No	n/a	Continuous	To various process units & WWT-156
127	Spent Catalyst Fines	0.1 kg/hr	No	n/a	Continuous	Vendor Reclamation
	Spent Catalyst Fines	0.1 kg/hr	No	n/a	Continuous	Vendor Reclamation
	Caustic	0.18 m^3/hr	No	n/a	Continuous	To unit Chemical Drain
128-01	None					
128-02	None					
129	Coalescing Element		Yes	Particulates	1 per yr	TBD
	Cartridge element		Yes	Particulates	1 per yr	TBD
131	Amine and oxygen scavenger	76.8 m^3/h	Yes	Toxic	Intermittent	Cooling water return or AOC Sewer
	Amine and oxygen scavenger	76.8 m^3/h	Yes	Toxic	Continuous	Cooling water return or AOC Sewer
	De-aerator overflow	88.8 m^3/h	No	n/a	Intermittent	AOC Sewer
132	Blowdown of cooling water	188060 kg/h	No	n/a	Continuous	Flow to AOC
	Backwash of SSF	596400 kg/h	No	n/a	Daily	Flow to AOC
	Spent Media	50 m^3	No	n/a	10 yrs	Landfill
	Spent Gravel	52.5 m^3	No	n/a	10 yrs	Landfill
133	Water, hydrocarbons and H2S mixture	5 m3/h	Yes	Toxic		Routed to oil drips system
	Water, hydrocarbons and H2S mixture	6.7 m^3/h	Yes	Toxic		Flare
	Water, hydrocarbons and H2S mixture	0.23 m^3/h	Yes	Toxic	Continuous	LP contaminated condensate system
134	Activated Alumina	22,000 kg	No	n/a	3-5 years	Landfill
137	Activated Carbon	2.0 m^3	No	n/a	3 yrs	Landfill
	Spent Resin	27.0 m^3	No	n/a	5 yrs	Landfill
	Spent Resin	27.0 m^3	No	n/a	4 yrs	Landfill
	Spent Resin	40.0 m^3	No	n/a	5 yrs	Landfill
	Spent Resin	59.9 m^3	No	n/a	4 yrs	Landfill
	Spent Anthracite	42.0 m^3	No	n/a	10 yrs	Landfill
	Spent Sand	42.0 m^3	No	n/a	10 yrs	Landfill
	Spent Gravel	10.8 m^3	No	n/a	10 yrs	Landfill

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
146	Sour Water	11 m^3/hr	No	n/a	Continuous	To Sour Water Treatment Unit
149	Wet Slops	34 m^3/hr	No	n/a	Continuous	To wet slops system
156	Sludge	1,900 m^3	Yes	Metals	per month	Incinerated-ash sent to secure landfill
	Dry Slops	3,200 m^3	No	n/a	Continuous	Incinerated-ash sent to secure landfill
	Spent Diesel, Dry Slops	3,200 m^3	No	n/a	Continuous	Incinerated-ash sent to secure landfill
	Wet Slops	950 m^3	No	n/a	Continuous	Incinerated-ash sent to secure landfill
	Biological Sludge	Variable	No	n/a	Continuous	Transported to NCC (National Cleaning Company)
165	Miscellaneous municipal waste (paper, plastics)	Variable	No	n/a	Continuous	Landfill
166	Miscellaneous Construction Waste (plastic, metal, wood, concrete, etc.)	Variable	No	n/a	Continuous	Landfill
186	Spent Catalyst	Unknown	No	n/a	TBD	
	Spent Catalyst	Unknown	No	n/a	TBD	
	Spent Catalyst	Unknown	No	n/a	TBD	
212	Spent Catalyst	1,005,782 kg	Yes	Metals	1/year	Landfill & Metals Recovery
	Fresh Catalyst Fines	1,000 kg	Yes	Metals	1/year	Landfill
	Hydrodrilling Water	650m^3 per batch	Yes	Dissolved Metals	1/year	Will not be treated with other refinery water
	Soda Ash Solution	Unknown	No	n/a	Intermittent	Unknown
213	Sour Water	38.5 m^3/h	No	n/a	Continuous	Routed to U-126 Sour Water Stripping Unit
	Dry Slops	10 m^3/h	No	n/a	Continuous	Routed to Dry Slops
214	Spent Guard Bed Catalyst	4.93 MT	Yes	Ignitibility, Toxicity	Every 2 years	Hazardous Waste Landfill
	Spent hydrotreating Catalyst	208.5 MT	Yes	Ignitibility, Toxicity	Every 2 years	Catalyst regeneration Company or Hazardous Waste Landfill
	Spent Hydrocracking Catalyst	610.7 MT	No	n/a	Every 2 years	Catalyst regeneration Company

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
	Broken inert Ceramic Balls	7 MT	No	n/a	Every 2 years	Industrial Landfill
216	All liquid discharges are collected and routed to other units for re-processing					
	Spent Catalyst	821.01 m^3	Yes	Metals	Continuous	Returned to the catalyst supplier for regeneration or metals recovery
	Filter Sludge	Minor quantities	No	n/a	As required	Incineration
249	Wet Slops	55 m^3/h	No	n/a	Intermittent	To Wet Slops System
	Utilty water	0.125	No	n/a	Intermittent	Drain to ODS Based on e evaporation losses
314	Wet Slops	58m^3/h	No	n/a	Continuous	To wet slops systems
	Wet Slops	58m^3/h	No	n/a	Continuous	To wet slops systems

10.4.1 Non-Hazardous Solid Waste Generation, Handling & Disposal

If existing areas for the temporary storage of non-hazardous wastes at the refineries are inadequate for the additional volume of waste produced by the CFP, additional facilities may be provided. No design work has been done during the FEED Phase for such an area, however non-Hazardous waste will be managed according to the KPC Corporate HSE Standard for Management of Waste Minimization and Disposal (Document 13.) Permanent waste disposal will be undertaken by K-EPA approved third parties located outside the refinery site.

Non-hazardous solid wastes will be generated during construction and operation of the CFP. Tables 10.1 and 10.2 above identify the likely non-hazardous solid wastes to be generated during operation at the new and revamped CFP units at MAA and MAB. Non-hazardous wastes likely to be generated during construction include but are not limited to:

- Spoil from excavation works for foundations
- Scrap steel and offcuts, including weldmesh, conduit, pipework, nuts, bolts, concrete reinforcing rods
- Timber waste from formwork and shipping crates
- Concrete, plaster board and cement sheeting
- Insulation materials
- Plastics from conduit and pipework
- Miscellaneous wastes e.g office waste, paper, food scraps, food containers and wrappings
- Packaging materials from equipment, material store and spare parts

Those handling and disposing of non-hazardous solid waste during the CFP will follow the following criteria:

1. Containers for storing various non-hazardous wastes will be selected for the specific service intended and shall be equipped with tightly fitting lids (except those used for inert non-blowing wastes). Lightweight plastic or paper bags will not be used alone, but may be utilized as liners for metal or plastic containers.

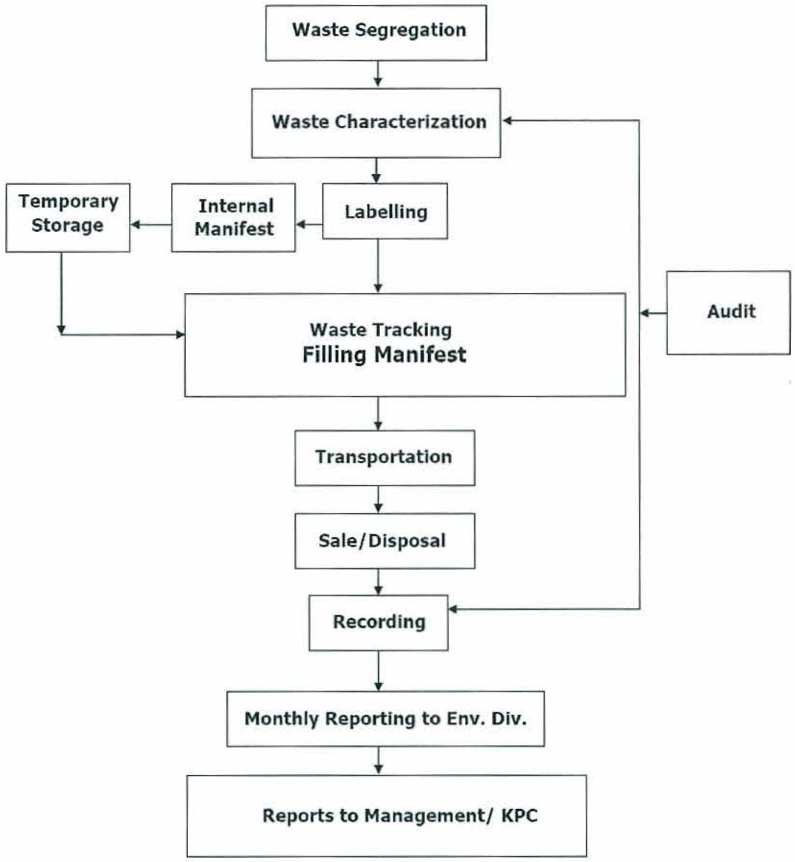
2. Refuse chutes and receiving areas will be designed to prevent the spread of fire or discharge of airborne pollutants or odours. The chutes and storage areas will be kept free of debris, and shall be cleaned and disinfected on a regular basis. Bulk containers will be readily accessible to collection vehicles.

3. Construction debris will not be allowed to accumulate and thus present a safety hazard for workers, or detract from the aesthetic values of the community. This material will be removed to the solid waste disposal site at the earliest opportunity and as the material is produced. This material will not be mixed with domestic type wastes.

4. Clean sand will not be mixed with construction debris.

Figure 10A below outlines the existing KNPC approach to Non-Hazardous Waste Management. This process is outlined in the current KNPC procedure for Solid Waste Management SHE-ESHU-03-1406.

Figure 10A - Non-Hazardous Waste Management Flowchart



10.4.2 Hazardous Waste Generation, Storage, Handling & Disposal

As a generator of hazardous wastes, the CFP will be required by Article No. 26 of the K-EPA regulations to obtain their identification number from K-EPA and to comply with the following K-EPA stipulations, as applicable:

- The waste production rate shall be reduced in quantity and quality by following clean technology and choosing alternatives of the product or raw materials that are less dangerous to the environment and public health e.g. selection of non-ozone depleting substances in refrigerant and fire protection systems; use of non-asbestos containing materials for insulation/gaskets; and use of non-PCB containing transformer oils. Waste reduction techniques include return of spent catalysts to suppliers for precious metals recovery.
- Transfer of waste outside the site will only be conducted by waste carriers with the appropriate K-EPA identification number and necessary licences from concerned authorities.

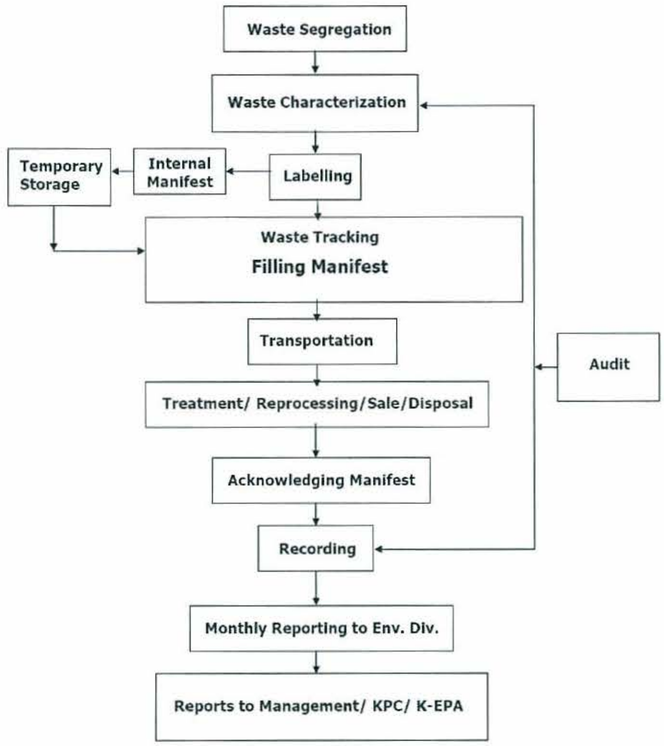
The CFP will include facilities for the temporary storage of hazardous wastes. The conditions for storing hazardous waste are stated in Article No. 30 of the K-EPA regulations as follows, and will be followed by KNPC:

(1) Separate substances either by isolating them in a separate facility or separate them in the same building by using insulated fireproof walls, or by leaving enough space or placing fireproof inert substances in between.
(2) Isolate the storage area away from buildings and other installations by erecting a proper fence, and forbid entry to everyone except to persons working in the area. Substances must be stored far from the fence area and in a well-organized way, by leaving enough space for easy movement between the stored materials. Open storage areas must be used to store secure substances only. Covering flammable waste must be done without flammable material covers to the extent practical.
(3) Storage sites must be in dry and ventilated areas.
(4) Waste must be stored in containers with edges to prevent any spillage.
(5) Storage areas must be emptied of flammable sources. Separate storage must be provided for liquid waste with a flash point less that 32°C. Highly flammable waste should be stored in refrigerators and cold storages.
(6) Substances should be classified according to their nature. Clear labelling with large letters so that substances can be distinguished.
(7) Labels should be place on stored containers so that flammable, oxidized or poisonous material can be easily distinguished. Labels should indicate the nature of substances, degree of toxicity and the right way of dealing with the substances in case of accidents or spillage. Labels should indicate the chemicals name as well as the commercial name and proper storage indicators.
(8) Separate oxidized waste from waste that it can react with. It must be stored in dry areas clear of flammable or acidic material.
(9) Unstable chemical substances that are easily solvent (i.e. highly volatile) must be stored in airtight containers and be kept cool and dark (i.e. temperature and humidity controlled). Large quantities of these substances must be stored in separate, non-confined areas to prevent damage by vapour cloud
(10) Gas cylinders must be stored away from flammable materials and heat sources.
(11) Waste must be stored in protected containers not prone to breakage or damage. Containers should be closed with covers that do not allow gas leakage and should be made easy to open.
(12) Glass containers that contain highly hazardous waste must be placed inside bigger containers, which will not react to the stored material.
(13) Contaminated stores or containers should be cleaned when closed.
(14) It is necessary to install an alarm system that will operate during emergencies. The alarm sound must be recognized and staff working in the stores must handle its mode of operation. It is necessary to supply the facility with a fire fighting system and necessary fire fighting equipment to resist fire or spillage.
(15) Daily record of stored substances must be supplied where the kind, quantity and area of storage must be recorded.

Hazardous wastes will be stored in secure areas that are paved, covered and curbed to contain any leakages or spills. Tanks containing hazardous materials or hazardous wastes that are liquid at standard conditions will be provided with secondary containment systems.

Figure 10B outlines the existing KNPC approach to Hazardous Waste Management that will be adopted at CFP. This process is outlined in the KNPC procedure for Solid Waste Management SHE-ESHU-03-1406.

Figure 10B - Hazardous Waste Management Flowchart



As part of the CFP project two new wastewater treatment systems (WWT) will be installed. One will be located at MAA Unit 163 and the other at MAB Unit 156.

These new facilities will incorporate state of the art design to complement upgrades to the existing MAB effluent treatment facility under a separate project (KNPC Effluent Treatment Facility Revamp project). The CFP design will incorporate best environmental engineering practices such as 'Best Available Control Technology' (BACT) to avoid, prevent or mitigate the discharge of all harmful emissions so as to meet (or exceed) applicable K-EPA environmental standards.

Both industrial and biological sludge will be generated from the CFP facilities. K-EPA Article No. 57 categorizes industrial sludge as follows:

- Oily sludge,
- Toxic sludge, and
- Chemical sludge.

The sludge collection and treatment system will collect and store sludge from the various pieces of WWT equipment.

For the MAB Refinery, biological treatment of wastewater from the CFP block will be carried out in the effluent treatment facilities (ETF) provided by a separate KNPC project. Waste activated sludge resulting from this treatment will be dewatered in the Sludge Dewatering facility which is also part of the separate ETF project and then shipped off-site to the NCC for disposal. Oily solids from the corrugated plate interceptor (CPI) and dissolved air flotation (DAF) separators, after removal of oil and water by centrifuging will be routed to the new CFP oil sludge incineration system at MAB (Unit 156).

At MAA, the collected sludge's are transferred appropriately into segregated storage tanks. The oily sludge collection systems will also be equipped with a vacuum truck disposal connection. The contents of each storage tank are treated in separate centrifuges to remove water and oil. The 25% solid content cakes generated by the centrifuges are loaded in roll-off boxes and transported to the appropriate sludge treatment and disposal facilities (i.e. biological sludge shipped to NCC and oily sludge routed to the new CFP oil sludge incineration system at MAB (Unit 156).

After dewatering, the oily sludge cake created at both MAB and MAA WWT facilities will be routed to a new CFP fluidised bed incinerator located at the MAB Refinery. Incinerator ash will be disposed in local landfills. A detailed description of the new WWT facilities is provided in Section 12 of this report.

10.5 Potential Impacts

The potential impacts on the surrounding environment from the generation, storage, handling, transportation and disposal of construction and operational non-hazardous and hazardous wastes have been identified by applying the impact assessment and matrix approach. The potential impacts and resulting significance are outlined in the figures below.

Figure 10C Impact Assessment Form and Matrix – Construction

Category: Environment **Consequence evaluation for: Solid Waste During Construction**

1. General description of the area (situation and characteristics)

Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

CFP will require new and modified facilities at the three KNPC Refineries and the use of a section of adjacent undeveloped land. The existing refineries, their surrounding areas/land and the section of adjacent undeveloped land are not considered to be highly sensitive areas.

In setting a sensitivity value relative to waste management during construction, the primary consideration is the integrity of the disposal sites for the construction waste. Construction wastes are likely to include:

- The generation of uncontaminated spoil which, if compatible, will be used as fill material within the CFP blocks. The sensitivity of the surrounding area to receiving such material will be negligible. Incompatible spoil will be transferred to an approved offsite landfill.
- Hazardous wastes and non hazardous wastes will only be disposed of at appropriate K-EPA approved facilities.

The potential impact following a release of hazardous waste also needs to be considered and the sensitivity of the area becomes relevant following failure of the prevention, control and mitigation barriers on site.

In assessing the sensitivity of the area, the relatively close proximity of the CFP to local populations (closest population approximately 2 km) needs to be evaluated along with what is considered to be a lack of adequate groundwater resources within this area. Based on this the sensitivity is deemed to be **Medium**.

Low Medium High
|---------X------------|

2. Description of the extent of effect	3. Total impact on environment
Evaluation of extent:	**"small negative impact""**

The main impact from the creation and storage of waste is the potential for a release to the surrounding environment. However, all hazardous waste will be properly bunded during the construction phase and adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge. All hazardous and non-hazardous wastes will be disposed of at appropriate waste management facilities.

The development of a waste management plan and waste procedures (by each EPC contractor) will reduce waste quantities, and continually improve re-use and recycling of construction waste. A central collection point will be allocated at the site to ensure segregation and maximise re-use and recycling.

The hazardous and non-hazardous solid waste produced as a result of the construction phase is likely to be of **small negative significance.** This evaluation is based on the effects being short-term, the fact that most of the wastes will be non hazardous, and the implementation of adequate management measures as discussed in this report.

Very neg. Medium neg. Little/no Medium pos. Very pos.
|---------------|--------------X--|----------------|-------------------|

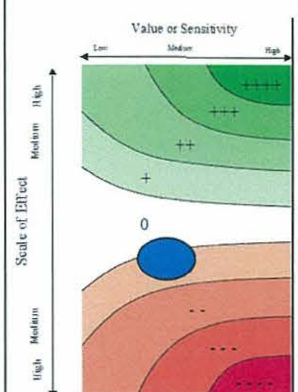


Figure 10D Impact Assessment Form and Matrix - Operations

Category: Environment	**Consequence evaluation for: Solid Waste During Operation**

1. General description of the area (situation and characteristics)

Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

In setting a sensitivity value relative to waste management during operation, the integrity of the disposal sites for the wastes is considered.

- Much of the hazardous wastes (spent catalysts) will be recycled prior to disposal by third party at appropriate licensed disposal facilities; facilities should only accept wastes if capable of treatment.
- Hazardous and Non-hazardous wastes will only be disposed of at appropriate K-EPA approved facilities.

An additional concern is the potential for a release of hazardous waste materials through spillages (e.g. oily wastes) to the surrounding environment.

As identified above for the construction phase the most important requirement is to ensure that measures are in place to properly manage hazardous waste. The sensitivity of the area only becomes relevant if these measures fail and spillages occur.

In assessing the sensitivity of the area, the relatively close proximity of the CFP to local populations (closest population approximately 2 km) needs to be evaluated along with what is considered to be a lack of adequate groundwater resources within this area. Based on this the sensitivity is deemed to be **Medium.**

Low Medium High
|---------X------------|

2. Description of the extent of effect	**3. Total environmental impact**

Evaluation of extent:

All hazardous waste from CFP facilities will be bunded and adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.

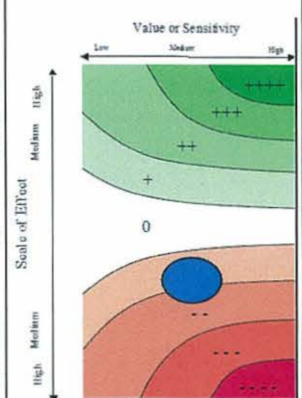
The impact on the environment will be mitigated by the implementation of robust waste management procedures that will reduce the impact on the environment caused by the generation of waste through operational activities at CFP facilities.

The hazardous and non-hazardous solid waste produced as a result of the CFP operation is likely to be of **small to moderate negative significance.**

This evaluation is based on the cumulative effects of waste disposal at appropriate licensed landfill sites (hazardous, non-hazardous), potential effects following incineration of hazardous waste and abnormal activities at the refinery such as spillage, and the implementation of all the management measures as recommended in this report.

Very neg. Medium neg. Little/no Medium pos. Very pos.
|----------------|-----X-------------|----------------|-------------------|

"Small to moderate Negative"



10.6 Mitigation Measures

10.6.1 Construction

A Waste Management Plan (WMP) will be developed as part of the construction phase of the CFP. The WMP will require all hazardous and non-hazardous waste to be tracked, segregated, as well as re-used and recycled where feasible to do so. The quantities of solid waste generated during construction is likely to be significant, however, the impact will be temporary.

Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.

10.6.2 Operation

The CFP will operate under an EMS, which will include a WMP. The WMP will incorporate the existing KNPC waste management procedures and practices (as described in section 10.4 above).

As defined in procedure SHE-ESHU-03-1406 on Solid Waste Management, a number of mitigating measures for the control of solid waste during the operational life of the CFP facilities will be implemented, the main ones being:

- All waste will be segregated, re-used and/or recycled wherever possible;
- Waste storage areas are required to be designed and built to meet K-EPA requirements
- Periodic waste reviews of operations will take place to identify how waste can be minimized further or eliminated in some cases;
- Facilities and equipment provided by this project will be designed to minimize the production of solid waste
- All hazardous waste will be stored in bunded or curbed areas with impermeable flooring. The waste manifest system will ensure correct categorization of hazardous solid waste, correct labeling, transportation, disposal and documentation;
- Non-hazardous solid waste will be segregated as much as possible in order to optimize the amount of material that can be reused or recycled.
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.

10.7 Conclusions and Recommendations

The CFP will generate a variety of wastes that are both hazardous and non-hazardous. For the purposes of this report the impacts of wastes generated through construction and operation phases of the project are considered separately.

The construction of the CFP will produce a variety of solid wastes (hazardous and non-hazardous). Similar waste types will be generated during the operational phase. In order to manage waste properly and comply with local and globally recognized waste management practices, a WMP will be developed by each EPC Contractor in accordance with KNPC policies/procedures as well as K-EPA requirements. Specifically, the WMP will comply with the existing KNPC Procedure for Solid Waste Management (SHE-ESHU-03-1406). The WMP will be developed as part of KNPC's existing EMS which will be extended to cover the CFP facilities.

As part of the WMP, a number of mitigating measures will be implemented. These will have the effect of reducing both the amount of waste generated, and the associated impacts on the environment.

An action plan for managing waste generated during CFP decommissioning activities should be developed by KNPC and submitted to K-EPA for review and approval prior to start of decommissioning activities.

In summary, the impact of the generation, storage, transportation and disposal of non hazardous and hazardous solid waste during construction is considered to be of **small** negative significance. This is due to temporary nature of the impact, the generation of a WMP and the full implementation of control measures as recommended in this report.

The impact of the generation, storage, transportation and disposal of non hazardous and hazardous solid waste during the operation of the CFP is considered to be of **small to moderate** negative significance. This is due to the quantities and nature of material, the presence of an EMS and WMP, and the full implementation of all control measures as recommended in this report.

11.0 Chemical Hazards Management

11.1 Chemicals Management

The new and modified CFP facilities will handle and/or store a variety of chemicals. KNPC's policy is to control chemical hazards and prevent exposure based on conformance to high standards of safety, health and personal hygiene, environmental protection and compliance to legislation and standards.

It is important to note that any decommissioning work carried out as a result of CFP will be discussed and evaluated in a separate document and is, therefore excluded from this EIS.

Materials being used within the various systems that comprise the CFP will include a variety of chemicals such as DMDS (Dimethyl Disulfide), sulphuric acid, caustic, chlorine and others, which if improperly managed can pose potential hazards to living organisms and/or the environment. These same chemicals, however, are currently being stored and used successfully within the existing refineries.

Hazardous materials may be solids, semi-solids, liquids, or gases and have one or more of the following characteristics:

- flammable
- corrosive
- reactive
- toxic
- radioactive
- dangerous to the environment
- potential biohazard.

The chemicals and facilities provided by the CFP will fall under the requirements of the KNPC Chemical Hazard Management Program (KNPC DDHE Procedure No.SHE-TSOH-04-1358) as well as KPC Corporate HSE Standard for Chemical Handling (Document 19). This program provides critical information for those working with chemicals including guidelines for:

- Specification, ordering, purchase, handling, storage, use, transportation, emergencies and disposal;
- Control of hazards; and
- Hazard communication.

The Material Safety Data Sheets (MSDS's) of all chemicals have to be approved (including paints, thinners etc) by the HSE Department before being used on site. During the operations phase, MSDS's will be made available at the guardhouse, administration building and control room buildings for the refineries. In addition, MSDS's will be accessible at the new chemical storage warehouse building and catalyst storage facility at the MAB refinery for the materials stored in those buildings. Employees will be appropriately trained in the handling of chemicals and will have access to the MSDS's. Labels and warning signs will be displayed as per K-EPA Hazmat labelling.

The categories of chemical hazards are defined in Appendix No. 10 of the K-EPA regulations. The categories include:

- Category 1 – Explosives. This category is further subdivided with respect to the nature of the explosive material.
- Category 2 – Compressed, liquefied gases or gases dissolved under pressure. This category is further subdivided into flammable gases, non-flammable and non-poisonous gases, and poisonous gases.
- Category 3 – Flammable Liquids.
- Category 4 – Solid flammable materials and materials exposed to automatic ignition and materials which when in contact with water emit flammable materials. This category is further subdivided into solid flammable materials, materials that are self-reacting and react with associated materials, and desensitized explosives.
- Category 5 – Oxidizing Factors and Organic Peroxides. Oxidizing materials and organic peroxides are treated as separate categories for the purpose of marking containers and packages and transport vehicles and for the purpose of separating the packages and transport.
- Category 6 - Poisonous and Contagious Materials.
- Category 7 - Radioactive Materials. This category includes the materials or set of materials which are automatically radioactive.
- Category 8 – Corroding Materials.
- Category 9 – Other Dangerous Materials.

Table 11.1 and Table 11.2 provide preliminary lists of chemicals that will require special management attention within the CFP facilities at MAA and MAB, respectively.

Table 11.1 Preliminary List of Chemicals Used in CFP Facilities that can potentially Create Chemical Hazards MAA Refinery*

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
46	Caustic		3,500 gallons	Liquid
99		None.		
107	Penex Reactor Catalyst		244.1m^3/hr	
	Puraspec 2443M		7.6m^3/hr	
	HPG-429		78.8m^3/hr	
	GB-217		5.7m^3/hr	
	ADS-12		17.30m^3/hr	
	Perchloroethylene		77.32m^3/hr	
	Caustic	50 wt% Caustic	14,672kg	
	Anhydrous HCL		5,002kg	
	Nitrogen		42354Nm^3	
125	CLR-204		41390 kg	
	GB-217		8480 kg	
	H-14271		196 kg	
129	Oxygen Scavenger		7 m^3	
	Amine		13 m^3	
135	DMDS		3,212 kg	
136	Ammonium Polysulfide	100 wt% Ammonium Polysulfide	2 Totes	Liquid
	Anti-Foam Agent		22,280 kg	
	Corrosion Inhibitor		20,093 kg	
	Deemulsifier		1,900 kg	
	Anti-Oxidant		7,000 kg	
137	Caustic Solution	20 wt% Sodium Hydroxide	Not Specified	Liquid
138	Caustic	20° Baumè Caustic	22 ft^3	

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
	Caustic Prewash	10° Baumè Caustic	141 ft^3	
	Caustic Regeneration	20° Baumè Caustic	866 ft^3	
141	Catalyst		1,004,234 kg	
	DMDS		78,047 kg	
	Anti Foaming Agent		As needed	
	Corrosion Inhibitor		As needed	
144	DMDS	100% Dimethyl Sulphide		
	Lubricity Additive			
	Anti-Foaming Agent			
	CPD Additives			
	Seal Oil			
	DN-3531 Catalyst	<30% Molybdenum <6% Nickel Oxide	398.6m^3	Solid
	SDD-800 Catalyst	0-0.7% Nickel Oxide	45.2m^3	Solid
	OptiTrap (MacroRing) Catalyst	68-82% Aluminium oxide 10-19% Molybdenum oxide 5-8% Phosphorous pentoxide 1-5% Nickel oxide	5.9m^3	Solid
	OptiTrap (Ring) Catalyst	68-82% Aluminium oxide 10-19% Molybdenum oxide 5-8% Phosphorous pentoxide 1-5% Nickel oxide	5.9m^3	Solid
	MaXTrap(Si) Catalyst	balance 5-10% Molybdenum oxide < 5% Nickel oxide	14.0m^3	Solid
	855MD "Medallions"	40% Alpha Alumina 60% Silicon dioxide	2.9m^3	Solid
	1,1 iminobis-2-propanol	100% 1,1 iminobis-2-propanol		liquid
146	None			
148	1" Ceramic Balls		8.75 m^3	
	½ " Ceramic Balls		0.8 m^3	

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
	1" Alumina Balls		1.67 m^3	
	½ " Alumina Balls		0.42 m^3	
	Hydro processing catalyst		13.8 m^3	
	Sulphur absorption catalyst		65.6 m^3	
	Steam reforming catalyst		21.7 m^3	
	Shift catalyst		7.4 m^3	
	Phosphate		450 kg	
	Morpholine		1400 kg	
150	MDEA	100% MDEA	1,445 m^3	
	Anti-Foam Chemical		2 m^3	
151-152	Ammonia	100 % Ammonia	Not Specified	Gas
	Phosphoric Acid	100 % Phosphoric Acid	15 kg	Liquid
	Anti-Foam Agent		0.4 m^3	
	Activated Carbon		2.4 m^3	
153	Anti-Foam Agent			
	Activated Carbon		2.1 m^3	
156	20% Caustic	20 wt% Sodium Hydroxide	1 m3	Liquid
163	Sulfuric Acid	98% Sulfuric Acid	306,294 kg	Liquid
	Methanol	100% Methanol	416,900 kg	Liquid
	Phosphoric Acid	Concentrated Phosphoric Acid	170,095 kg	Liquid
	Caustic	20% Sodium Hydroxide	16,134,030 kg	Liquid
166	Biocide		8,400 kg	
171	Activated Alumina		20,700 kg	
174	Amine Antifoam		240 kg	
175	Chlorine Gas	100% Chlorine	16,700 kg	Gas
	20% Caustic Solution	20 wt% Sodium Hydroxide	72,500 (14) kg	Liquid
176	Caustic (50%)	50% Caustic Solution	289,260 kg	Liquid
	Sulfuric Acid (98%)	98% Sulfuric Acid	120,330 kg	Liquid
	Chlorine	100% Chlorine	13 kg	Gas

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
183	Antifoam Emulsion		385 kg	
186	DMDS	100% DiMethyldiSulfide	17,053 kg	Liquid
195	20% Caustic	20% Sodium Hydroxide	208 ft^3	Liquid
283	None			

(1) Units were selected from MAA Refinery Work Breakdown Structure (WBS), P6001MAA-000.10.10.002_Rev.N. New Licensed and Open Arts process Units and new Utility and Offsites Units were included.

(2) Chemical properties and special handling requirements are provided in Material Safety Data Sheets (MSDSs).

* CFP facilities will handle and store a variety of proprietary catalysts which are not listed here. The handling and disposal of spent catalyst material is discussed in Chapter 10 (Solid Waste).

Table 11.2 Preliminary List of Chemicals Used in CFP Facilities that can potentially Create Chemical Hazards MAB Refinery*

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
11	Caustic Solution	Sodium Hydroxide Solution	30 - 40 gallons/hr	liquid
16	DMDS	100% DimethylDisulfide	118,912 liters	liquid
111	Caustic Solution	20 wt% Sodium Hydroxide	0.0053 m3/hr	liquid
	Ammonia Solution	5 wt% NH4OH	0.014 m3/hr	liquid
112	DMDS	100% DimethylDisulfide	154,253 kg	liquid
	Anti-Foaming Agent		As needed	
113	None			
114	DMDS	100% DimethylDisulfide	195,000 kg	liquid
115	DMDS	DimethylDisulfide	56,839 kg	liquid
116	DMDS	DimethylDisulfide	100 tonnes	liquid
	Anti-Foaming Agent			
117	DMDS	100% DiMethylDiSulfide	17,053 kg	liquid
118	Phosphate		1,400 kg	
	Morpholine		48,000 kg	
119	Amine Antifoam		770 kg	
	PSA Adsorbant			
123	Ammonia	100% Ammonia	5 cylinders	gas
	Phosphoric Acid	100% Phosphoric Acid	133 kg	liquid
	Anti-Foaming Agent		90 m^3	
	Activated Carbon		5.3 m^3	
125	MDEA	100% MDEA	3, 500 m^3	
	Activated Carbon		91 m^3	
126	Caustic solution	20% Sodium Hydroxide	400 m^3	liquid
128	Amine Antifoam		1, 172 kg	
129	Amine		1.43 litres/hour	
131	Oxygen Scavenger		18 m^3/yr	
	Amine		38 m^3/yr	
132	Biodispersant		6,100 kg	

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
	Chlorine Gas		43,300 kg	
	Caustic Solution	20% Caustic Solution	165,100 kg	
134	Activated Alumina		36,900 kg	
137	Caustic (50%)	50% Caustic Solution	578,520 kg	liquid
	Sulfuric Acid (98%)	98% Sulfuric Acid	240,660 kg	liquid
	Chlorine	100% Chlorine	26 kg	gas
154	Biocide		8,400 kg	
156	Sulfuric Acid	98% Sulfuric Acid	3,400 kg	liquid
	Caustic Solution	20 wt% Sodium Hydroxide	1,220,000 kg	liquid
	Ferric Chloride		152,100 kg	
	Chlorine	100% Chlorine	220 kg	gas
	Sodium Biocarbonate		370,000 kg	
	Activated Carbon		6,200 kg	
212	DMDS	100% DimethylDisulfide	77,127 kg	liquid
	Anti-Foaming Agent		As needed	
213	Antifoam Emulsion		385 kg	
214	DMDS	100% DimethylDisulfide	119,850 kg	liquid
	Soda Ash	Na_2CO_3	14,430 kg	
	Sodium Nitrate	$NaN0_3$	2405 kg	
216	DMDS	100% DimethylDisulfide	150 tonnes	
	Anti-Foaming Agent		TBD	
	Activated Carbon		2.4 m^3	

(1) Units were selected from MAA Refinery Work Breakdown Structure (WBS), P6001MAA-000.10.10.002_Rev.N. New Licensed and Open Arts process Units and new Utility and Offsites Units were included.

(2) Chemical properties and special handling requirements are provided in Material Safety Data Sheets (MSDSs).

* CFP facilities will handle and store a variety of proprietary catalysts which are not listed here. The handling and disposal of spent catalyst material is discussed in Chapter 10 (Solid Waste).

11.2 Chemical Handling and Storage

Potentially hazardous chemical materials will be handled, treated, stored and disposed of in the manner that is consistent with KNPC SHE Criteria during CFP construction and operations. The appropriate handling and danger placards will be displayed wherever hazardous chemical materials are handled, transported or stored. Storage will be in accordance with the provisions of Article No. 30 of the K-EPA regulations.

11.2.1 Construction

Construction of the CFP will require the use of numerous chemicals and materials including but not limited to:

- Paints
- Thinners
- Acids
- Solvents
- Lubricating oils
- Diesel for generators
- Compressed gases
- Pest control chemicals
- Cleaning fluids
- Corrosives

Only zero VOC paints will be used during construction of the CFP. Formaldehyde containing paints/ varnishes will not be used and care will be taken not to mix potentially incompatible materials. The temporary storage area (discussed below) will be required to comply with all local regulations. Fire fighting, safety and spill control equipment will be readily available should an accidental materials hazard occur. Personnel training will be provided regarding the proper use and upkeep of all emergency response equipment.

During construction, all hazardous material will be stored and managed in a central location located within each EPC Contractor controlled area. Materials within these areas will be stored according to compatibility and all flammable materials will be segregated and stored in a flame protected area. All hazardous materials will be contained within temporary or permanent bunding in order to prevent a release to soil and/or groundwater.

11.2.2 Operation

Potentially hazardous materials storage during operation of CFP facilities will either be in fixed tanks (at various bunded locations on the site), in a compressed gas cylinder storage area, or in the new MAB Chemical Storage Warehouse/ Catalyst Storage Area.

These facilities may contain hazardous materials in bottles, pails, drums, bags, or other containers. The design, construction and operation of these facilities will be in accordance with K-EPA licensing requirements as specified under Article No. 18 and the United Nations Classification System for separation of hazardous chemical materials. In addition, storage requirements and handling procedures will be in accordance with the requirements of KNPC's Chemical Hazard Management Procedure. Category 1 explosive materials are not envisaged for the CFP.

Chemical Storage Warehouse (Figure 11A)

- Two single story buildings
- Reinforced concrete slab and foundation
- Firewalls to separate materials that are combustible, flammable, corrosive or toxic, including acids and alkalis.
- Chemical resistant coating such as an epoxy on floor
- Curbing will be used to provide secondary containment where needed

Catalyst Storage Area (Figure 11B)

Fresh catalysts are typically not hazardous when properly handled. They are composed of alumina and silica substrates which contain oxides of molybdenum, cobalt, nickel and possibly other active metals such as platinum or palladium. The metal oxides and substrates are stable compounds under ambient conditions. After catalysts become spent, they are classified as hazardous waste because the metal oxides are converted to sulfides and other metals such as vanadium are accumulated within the catalyst structure. The metal sulfides, in the presence of hydrocarbons, can be pyrophoric under certain circumstances.

A new Catalyst Storage Area will be provided for fresh catalysts. It will consist of:

- Five single story, covered metal sheds
- Reinforced concrete slab and foundation
- Floor epoxy finish coating
- Steel pallet rack system finished with factory applied heavy duty corrosion resistant coating system
- Will contain catalyst packed in super sacks placed on pallets
- Catalysts in 55 gallon drums will be stored in the open yard.

Figure 11A – Chemical Warehouse Building Conceptual Site (drawing is preliminary and subject to change)

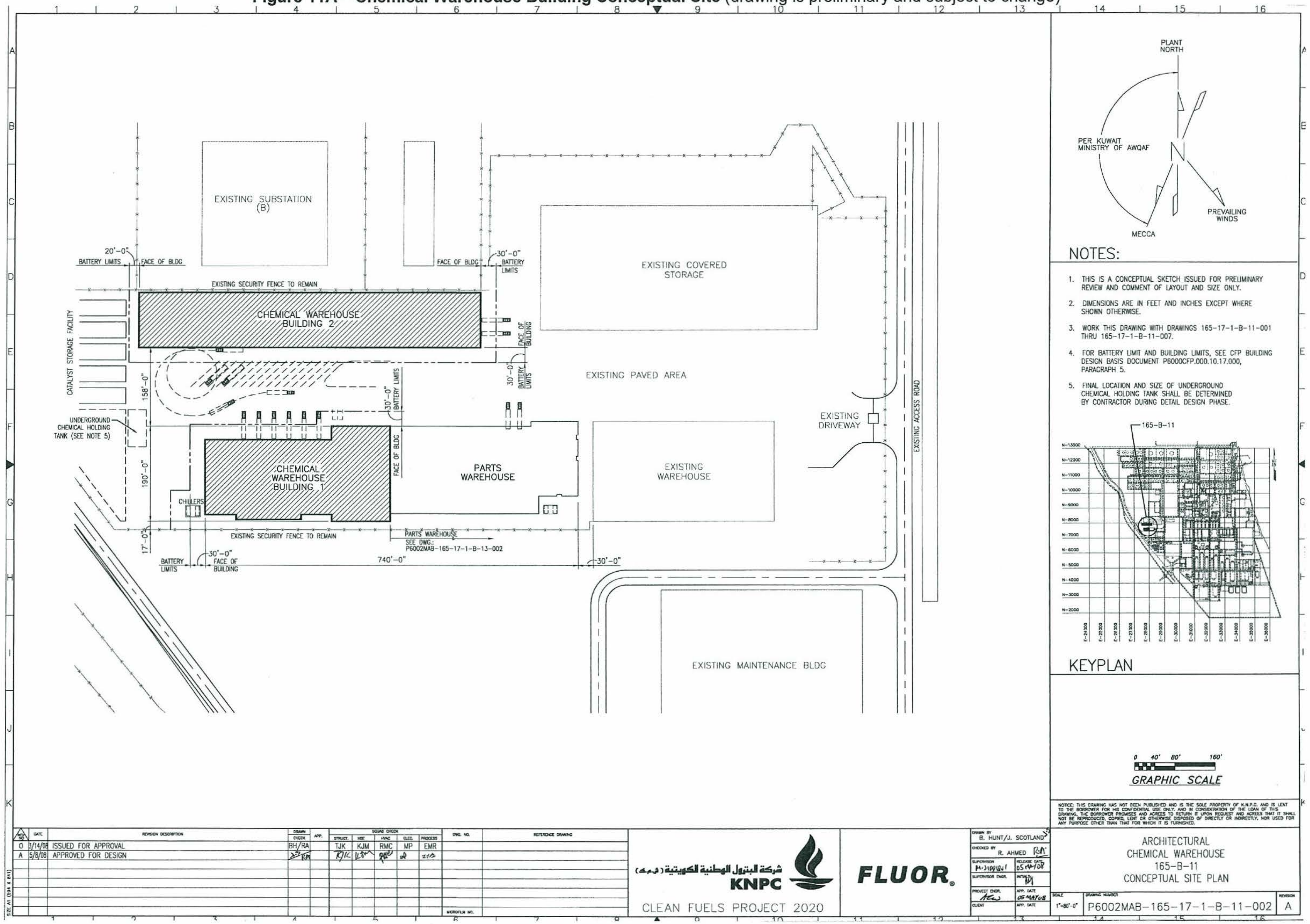
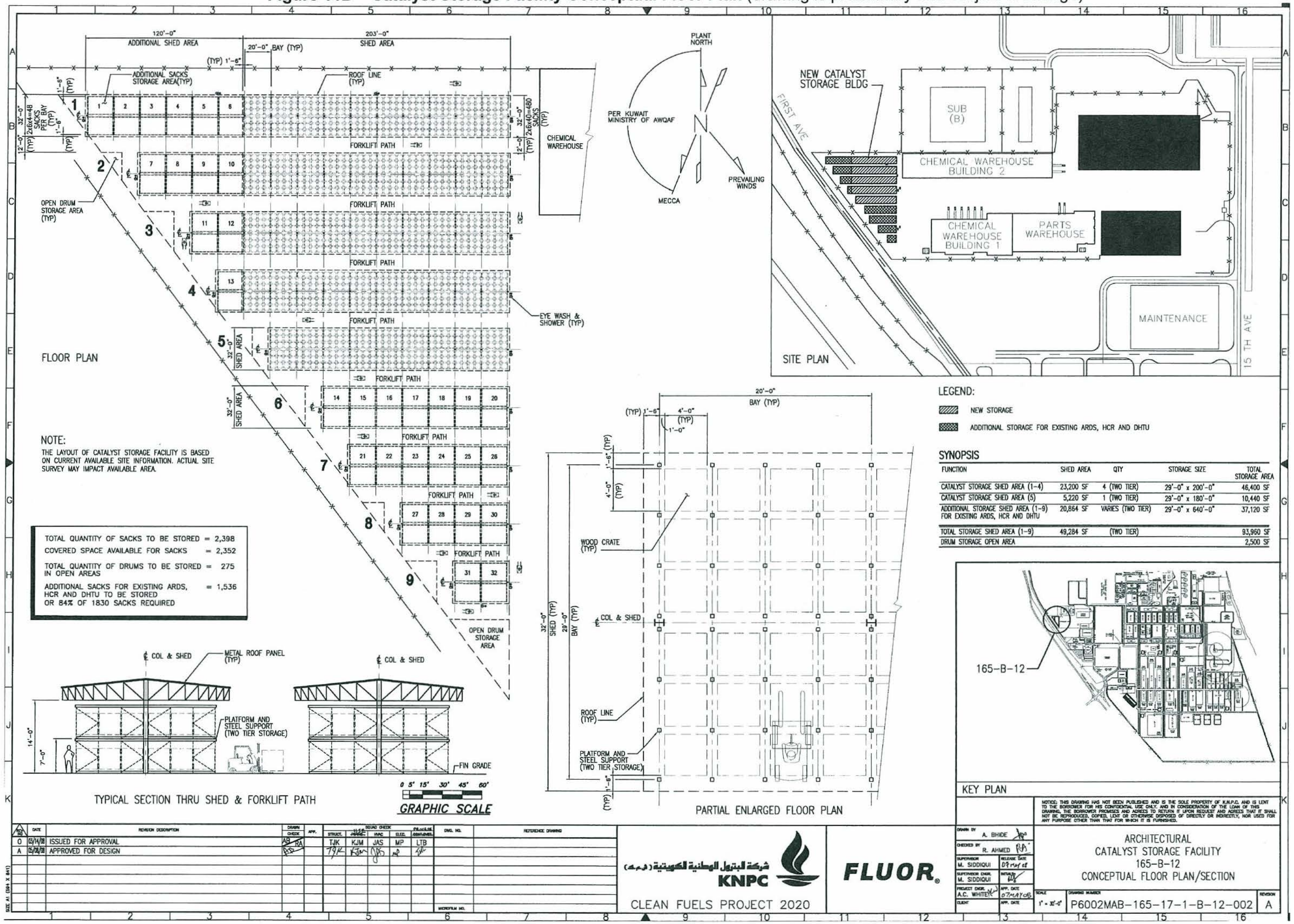


Figure 11B – Catalyst Storage Facility Conceptual Floor Plan (drawing is preliminary and subject to change)



FUNCTION	SHED AREA	QTY	STORAGE SIZE	TOTAL STORAGE AREA
CATALYST STORAGE SHED AREA (1-4)	23,200 SF	4 (TWO TIER)	29'-0" x 200'-0"	46,400 SF
CATALYST STORAGE SHED AREA (5)	5,220 SF	1 (TWO TIER)	29'-0" x 180'-0"	10,440 SF
ADDITIONAL STORAGE SHED AREA (1-9) FOR EXISTING ARDS, HCR AND DHTU	20,864 SF	VARIES (TWO TIER)	29'-0" x 640'-0"	37,120 SF
TOTAL STORAGE SHED AREA (1-9)	49,284 SF	(TWO TIER)		93,960 SF
DRUM STORAGE OPEN AREA				2,500 SF

KNPC will implement the following procedures for handling and storage of hazardous materials:

- Areas for storage of hazardous materials in any form (tanks, drums, solids, etc.) will have a spill containment system for collecting and holding spills, leaks, and precipitation;
- Any hazardous waste generated will be placed in sealed plastic or metallic drums with an inner polybag liner prior to being transported to an approved disposal site in accordance with applicable K-EPA criteria;
- Any container holding a hazardous material or hazardous waste will be kept closed during storage;
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge of hazardous materials;
- Written documentation for storage, handling, transportation, and disposal of hazardous materials and hazardous wastes will be maintained at the MAA and MAB refineries including a record of quantities, hazardous characteristics, and MSDS's;
- Access to any hazardous material storage area will be controlled to prevent entry of unauthorized persons or vehicles;
- Incompatible materials will not be placed in common containment areas or in the same containers in accordance with the requirements of K-EPA Article No. 18;
- Source monitoring systems will be provided in appropriate areas of the MAA and MAB refineries for detection of combustible gas.

11.3 Storage and Handling Design Basis

11.3.1 Secondary Containment

All new CFP vessels for handling or storing hazardous materials will be constructed of appropriate materials for the contents they hold and will have epoxy or similar lining as necessary to prevent corrosion and /or leaks. All new tanks in hydrocarbon and/or hazardous material service will have dike walls around the tank as well as provision of secondary containment below the tank. Secondary containment and storage requirements for hazardous materials will be in accordance with K-EPA Article No. 30 and accepted international criteria.

New or modified process vessels containing hazardous materials will be located above a concrete pad that is curbed to contain any potential spills or leaks.

A pump out system (either a permanent installation or a temporary/portable system) will be provided for draining more than 10m^3 of hydrocarbons resulting from an accidental leak or spill. Spilled oil or chemicals will be collected to the extent practical by vacuum truck and then taken to the waste water treatment system. Any remaining oil or chemicals will be washed down into a sump that is part of the Oil Drips System (ODS). The ODS is an underground, gravity drain which leads to a central sump feeding into the CFP wastewater treatment facilities.

In addition, a groundwater monitoring well system will be installed and located so that representative samples of the groundwater that may be impacted by operation of the proposed facility can be obtained. A total of three up gradient and five down gradient groundwater monitoring well systems will be placed around each CFP process block within MAA and MAB refineries. The groundwater monitoring well systems will be capable of measuring background water quality and intercepting/measuring plumes of contamination, if any, from the facility operations. Groundwater monitoring well placement will be based upon hydrogeological data for the refinery sites taking into account both the direction of groundwater flow and the planned location of facilities/equipment where oil and other potentially hazardous materials will be stored.

A chlorine gas feed system is currently used to treat cooling water within the existing refineries. The new cooling water systems for the new and modified CFP facilities will also use chlorine however the chlorine gas cylinders will be stored within enclosed buildings. Enclosure of the cylinders within specifically designed buildings will ensure containment in the event of a release. There are two chlorine system enclosures planned for MAA and two planned for MAB. They will all include leak detection systems/alarms and caustic scrubbers. Chlorine will not be used during the construction phase. Chlorine modelling should be conducted in order to ensure that any safety issues are adequately addressed.

11.3.2 Transportation of Hazardous Chemical Materials

Where transportation of hazardous materials or hazardous waste is required for disposal outside the CFP, this will be conducted in accordance with K-EPA criteria (Article Nos. 31 through 34) and good environmental operating practices. On-site collection system containers and storage areas will be kept well segregated in order to prevent the creation of health and fire hazards. The transportation of hazardous waste is discussed in detail in Chapter 10 (Solid Waste Management).

11.3.3 Underground Storage of Hazardous Chemical Materials

The CFP scope does not currently include any plans for underground storage tanks. However, there will be a number of underground piping, vessels (such as drains and sumps) as part of the various wastewater collection systems for CFP. All underground piping will be hydro-tested before operation commences.

11.3.4 Spill / Release Control and Contingency Planning

KNPC is committed to the safety of its employees, installations and the society. All applicable safety standards, procedures and best practices are followed during process selection, design, construction and operation of the various facilities. However, even with the best safe working practices, emergency incidents may occur. Therefore, as part of its overall EMS, KNPC has developed procedures for emergency response. The design and operation of CFP facilities are incorporated into KNPC's existing emergency preparedness and contingency planning procedures. These procedures include descriptions of the specific requirements for handling and disposal of hazardous materials, and emergency response. This is discussed in Chapter 15.

11.4 Potential Impacts

The potential impacts on the surrounding environment from the storage, use, handling and transportation of potentially hazardous materials have been identified by applying the impact assessment and matrix approach. The potential impacts and resulting significance are outlined in Figures 11C and 11D below.

Figure 11C Impact Assessment Form and Matrix - Construction

Category: Environment

Consequence evaluation for: Hazardous Material Management during Construction

1. General description of the area (situation and characteristics)

Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

CFP will require new and modified facilities at the three KNPC Refineries (MAA/MAB/SHU) and the use of a section of adjacent undeveloped land. The existing refineries, their surrounding areas/land and the section of adjacent undeveloped land are not considered to be highly sensitive areas.

It is important to note the decommissioning phase of the project is not included as part of this EIA and its impact in relation to hazardous material management has therefore not been evaluated.

It is difficult to apply a sensitivity value (using this matrix) to hazardous material management during either construction or operation, as the important issue is to ensure that measures are in place to properly manage hazardous materials. The sensitivity of the area only really becomes relevant if these measures fail and spillages occur.

In assessing the sensitivity of the area the relatively close proximity of the CFP to local populations (closest population approximately 2 km) needs to be evaluated along with what is considered to be a lack of adequate groundwater resources within this area. Based on this the sensitivity is deemed to be **Medium**.

Low Medium High
|---------X-----------|

2. Description of the extent of effect

Evaluation of extent:

The main impact from the storage of hazardous material is the potential for a release to the surrounding environment. However all hazardous materials will be properly bunded and contained and adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.

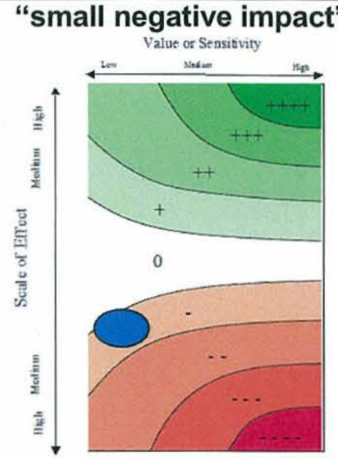
Hazardous material management procedures will be implemented and therefore help to prevent and minimise any potential effects.

The quantities of hazardous material likely to be stored and used on site during the construction phase are likely to be relatively small. The extent of the effect is assessed to be of **Little significance** provided recommended measures are followed.

Very neg. Medium neg. Little/no Medium pos. Very pos.
|---------------|--------------X--|----------------|-------------------|

3. Total (environmental) impact

"small negative impact"



MANAGING RISK DNV

Figure 11D Impact Assessment Form and Matrix - Operations

Category: Environment
Consequence evaluation for: Hazardous Material Management during Operation

1. General description of the area (situation and characteristics)

Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

As identified above for the construction phase the most important requirement is to ensure that measures are in place to properly manage hazardous materials. The sensitivity of the area only really becomes relevant if these measures fail and spillages occur.

In assessing the sensitivity of the area the relatively close proximity of the CFP to local populations (closest population approximately 2 km) needs to be evaluated along with what is considered to be a lack of adequate groundwater resources within this area. Based on this the sensitivity is deemed to be **Medium.**

Low Medium High
|---------X-----------|

2. Description of the extent of effect

Evaluation of extent:

The CFP project will use and store significantly large quantities of finished product, chemicals and catalyst during its operation. The biggest risk to the environmental is likely to result from an on-site release of large quantities of hazardous material.

A large number of mitigation measures will be implemented at the site and these need to be taken into account in this evaluation:

The large quantities of hazardous material will be bunded and an impermeable lining/membrane will be present under the hydrocarbon tanks (although areas extending outwards from the sides of tanks will not be impermeable). Chlorine gas cylinders will be stored in enclosed buildings which include leak detection systems/alarms and caustics scrubbers

Hazardous material management procedures will be in place in order to prevent and minimise any potential effects and the approach to hazardous waste materials management during operation is prevent, minimisation, re-use, recycle.

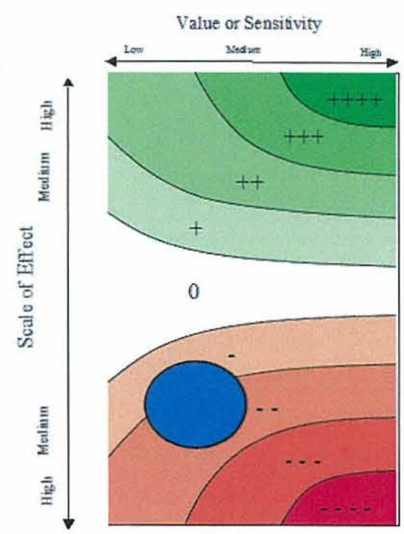
Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge of hazardous materials.

Provided the management measures advised are taken, this issue is assessed as having **Medium negative significance**

Very neg. Medium neg. Little/no Medium pos. Very pos.
|---------------|-----X-----------------|---------------|------------------|

3. Total (environmental) impact

"Medium negative impact"



11.5 Mitigation Measures

11.5.1 Construction

- A central location will be defined within each EPC Contractor storage controlled area for the storage and management of all hazardous material during construction.
- All materials will be stored according to their compatibility and will be contained within temporary or permanent bunding to prevent the release to soil and/or groundwater. All flammable material will be segregated and stored in flame proof areas.
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.
- Any hazardous waste generated during construction will be disposed of according to the WMP (refer to Chapter 10).

11.5.2 Operation

A number of mitigating measures for the control of hazardous materials during operation of the CFP facilities are proposed, the main ones being:

- A groundwater monitoring well system will be installed. These wells will be installed based upon hydro-geological data for the refinery sites taking into account both the direction of groundwater flow and the planned location of facilities /equipment where oil and other potentially hazardous materials will be stored. The groundwater monitoring well system will be capable of measuring background water quality and intercepting/measuring plumes of contamination, if any occur from the refineries operations;
- Storage of hazardous chemicals will be in accordance with the provisions of Article 30 of the K-EPA regulations ensuring that the storage and handling of materials are properly managed;
- A Chemical Storage Warehouse will be built at the MAB Refinery. It will consist of two buildings both of which will be unoccupied. The warehouse will store all chemicals used at the MAB refinery and will be designed to include firewalls to separate materials that are combustible, flammable, corrosive or toxic including acids and alkalis; A new Chemical Warehouse is not planned for the MAA Refinery.
- A Catalyst Storage Area will be constructed at MAB, which will consists of five single story covered metal sheds and an open yard area for drum storage; A new Catalyst Storage Area is not planned for the MAA Refinery.
- Curbs, floor drains, sumps and trench drains with grating will be provided in the storage areas for spill control and containment of liquids and water discharge from sprinkler systems and emergency shower eyewash. The floor drains and sumps in curbed areas and floor trenches at doors will be connected by chemical resistant piping to drain to an underground collecting/holding tank. The holding tank will be adequately sized to contain releases;
- Areas for storage of hazardous materials in any form (tanks, drums, solids, etc.) will have a spill containment system for collecting and holding spills, leaks, and precipitation. All tanks containing hydrocarbons and/or hazardous material will be bunded and lined with an impermeable membrane;
- A leak detection system will be in place serving the new hydrocarbon and hazardous material storage (whose contents are in a liquid state at ambient conditions) tanks. For areas other

than that directly below storage tanks, leak detection will be accomplished through regularly scheduled visual inspection of the tank exterior and connecting piping;

- Any hazardous waste generated will be placed in sealed plastic or metallic drums with an inner polybag liner prior to being transported to an approved disposal site in accordance with applicable K-EPA criteria;
- Any container holding a hazardous material or hazardous waste will be kept closed during storage;
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge of hazardous materials;
- Written documentation for storage, handling, transportation, and disposal of hazardous materials and hazardous wastes will be maintained including a record of quantities, hazardous characteristics, and MSDSs;
- Access to any hazardous material storage area will be controlled to prevent entry of unauthorized persons or vehicles;
- Incompatible materials will not be placed in common containment areas or in the same containers in accordance with the requirements of K-EPA Article No. 18;
- Source monitoring systems will be provided in appropriate areas of the CFP project for detection of combustible gas;
- The chlorine system enclosures will all include leak detection systems/alarms and caustic scrubbers.
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge;
- Disposal of hazardous waste will be in accordance with the requirements of the EMS.

11.6 Conclusions and Recommendations

The CFP facilities will store and/or handle a variety of potentially hazardous materials, including materials similar to what currently exist at the three refineries. The hazardous materials to be used on the site (the majority of which are identified above) will be potentially toxic, corrosive, flammable etc.

The impact from the storage, use, transportation and disposal of hazardous materials is considered to be "little negative" significance during construction and of "medium negative" significance during operation provided that all recommended management measures are followed.

It is important that the management systems comply with K-EPA requirements for the handling, storage and disposal of hazardous materials. Storage of hazardous chemicals will be in accordance with the provisions in Article 30 of the K-EPA regulations.

During construction and operation, hazardous material will be controlled by appropriate management procedures. Mitigation measures will be introduced during construction and operation that will ensure containment of materials either via temporary bunding during construction or permanently via the specifically designed MAB Chemical Warehouse.

12.0 WASTEWATER GENERATION, TREATMENT AND REUSE

12.1 Introduction

The CFP development will require large volumes of water for cooling tower, boiler feedwater (BFW) make-up, process water, potable water, sanitation and other refinery services. KNPC plans for the CFP's water demand to be met by wastewater recycling and reuse as much as possible.

Minimization of wastewater generation at the source and by reuse, as well as segregation, collection and treatment of similar wastewater streams are the main principles used in the design of the cost effective and environmentally friendly wastewater treatment. The new Wastewater Treatment (WWT) Systems will collect, convey and treat wastewater according to the K-EPA requirements prior to any discharge.

There will be two new WWT Systems provided as part of the CFP:

- New Wastewater Treatment System at MAA – Unit 163
- New Wastewater Treatment System at MAB – Unit 156.

These new CFP facilities will incorporate state of the art design to complement upgrades to the existing MAB effluent treatment facility under a separate project (KNPC Effluent Treatment Facility Revamp project). The CFP design will incorporate best environmental engineering practices such as 'Best Available Control Technology' (BACT) to avoid, prevent or mitigate the discharge of all harmful emissions so as to meet (or exceed) applicable K-EPA environmental standards.

The objectives of the WWT Systems are:

- Compliance with K-EPA Regulations for effluent discharges to the sea
- Simplify treatment and reduce cost of wastewater treatment by segregation, collection, and treatment of similar types of wastewater
- Uninterrupted treatment of incoming wastewater using equipment redundancy and WWT system flexibility
- Minimize Volatile Organic Carbon (VOC) emissions and reduce odour
- Reuse treated effluent water for fire water make-up and utility hose stations.

The focus on this wastewater section is on the following areas:

- Explain the details of the new WWT Systems
- Identify wastewater streams
- Identify wastewater minimization, reuse, treatment and recycling
- Assess the impact of discharges during both CFP construction and operation.

12.2 Wastewater (Construction)

It is expected that an overall peak workforce of approximately 36,000 (divided into separate EPC contractor camps) will be required at the peak of construction activities for the CFP. The workers will be housed in the local community, existing camps and potentially new camp facilities to support the project.

In all cases, plans for handling site drainage and wastewater discharge are currently not well defined. It can be stated that KNPC, and the EPC contractors, are committed that all discharges will meet regulatory requirements during construction. This is particularly important bearing in mind that groundwater onsite is currently contaminated with coliforms in some locations.

Wastewater effluents will be generated on a short-term basis as a result of the various construction activities associated with the CFP, and its scheduled start-up and maintenance activities. These will include sanitary wastewater, wash-down water, storm water, and wastewater from hydrostatic testing activities (i.e. from asset-integrity testing of pipelines and storage tanks etc). The EPC contractors will be required to develop a hydrostatic testing procedure which must be approved by KNPC and Fluor (as PMC). All hydrostatic test water must meet all applicable K-EPA criteria, such as pH, before being discharged.

Specific wastewater collection and treatment elements during the CFP's construction phase will include:

- Sanitary wastewater collection/treatment: The current basis for treating the construction sanitary wastewater is not well developed. It may involve the utilization of temporary facilities such as portacabins and holding tanks to collect and contain sanitary wastewater. Wastewater would then be periodically removed from the site via vacuum tanker trucks to an approved existing government-owned wastewater treatment facility. KNPC and the EPC contractors are committed that all discharges will meet regulatory requirements during construction. This is particularly important bearing in mind that groundwater on the refinery sites is currently contaminated with coliforms in some locations.

- Storm water from the CFP construction site and groundwater from groundwater pumpout activities will be contained and collected onsite and tested to meet K-EPA requirements before discharge via existing storm water discharge outlets at MAA or MAB. If the water quality is not acceptable, the EPC contractor will need to provide means for treating the water prior to discharge (existing refinery wastewater treatment facilities will not be used for treatment of construction drainage). No new discharge outlets will be provided during construction.

  During the early stages of construction, the volume of storm water to be collected at the CFP construction site is expected to be minimal. However, there will be a gradual increase in storm water collection over time as the amount of paved area within the CFP site increases. Specific plans and details for handling site drainage during construction are currently not well defined at this stage, although each EPC Contractors is responsible to adhere to Project and Regulatory Requirements.

K-EPA requires that all treated effluent discharges to sea be 500m or more offshore. A new outfall pipeline will be provided from the CFP wastewater treatment facilities at MAA in accordance with this requirement. This outfall will not however exist during the early construction phase. It is KNPC's policy that throughout the construction period no wastewater effluents will be discharged to the environment (either to land or sea) without first having been analyzed to verify compliance with all applicable K-EPA discharge criteria. If sample analysis indicates that the water in the retention pond(s) is not of acceptable quality for discharge it will be pumped back to the packaged wastewater treatment or collected via vacuum truck for transport to an appropriate wastewater treatment facility.

Before any storm water, groundwater and treated effluent is permitted to exit from the collection areas, it will be sampled and analyzed for compliance with the applicable regulatory criteria. Only water that is equal to or of better quality than that of the natural occurring drainage will be released. The flow of clean water from the collection areas will be gradual and normally low in volume. In the case of a large rainfall event, the collection areas may be pumped down rapidly to avoid flooding the CFP construction site and surrounding area.

Each EPC Contractor will be required to submit, for KNPC approval, a Water Conservation and Wastewater Management Plan that will detail their prescribed methods toward minimizing the generation of wastewater effluents, and wastewater management including sewage, wastewater and storm water.

12.3 Wastewater (Operation)

12.3.1 Overview of Wastewater Treatment Facilities

The main wastewater streams treated in the WWT units are process wastewater streams from the CFP units, such as surplus Stripped Sour Water (SSW), Cooling Tower (CT) blowdown, Boiler blowdown, as well as fire fighting water and storm water runoff from paved process areas.

Clean CFP storm water from MAA (OSBL) is released into an existing concrete lined ditch along the south side of MAA and winds through the refinery to make its way to a wadi near the southeast corner of MAA. KNPC currently use this wadi to receive clean storm water from existing areas of MAA. Storm water runoff from MAB areas and roadways outside paved process areas is collected in an oil catcher and pumped to the Gulf.

The effluent streams generated and collected from the new CFP process units are segregated at the source and collected in one of following seven drainage systems as discussed further in Section 12.3.3. Effluents segregated and collected in these drainage systems receive different treatment, depending on the source, type and level of contamination.

- Accidentally Oil Contaminated (AOC)
- Oily Drips System (ODS)
- Chemical Collection and Drainage System
- Dry Slops System
- Outside Battery Limits (OSBL) and Roadway Storm Water Drainage System
- Sanitary and Gray Water Collection
- Sludge Collection and Treatment

These new CFP WWT facilities will incorporate state of the art design. The CFP design will incorporate best environmental engineering practices such as 'Best Available Control Technology' (BACT) to avoid, prevent or mitigate the discharge of all harmful substances so as to meet (or exceed) applicable K-EPA environmental standards.

The new CFP WWT plants will treat wastewater streams from various CFP process areas. At MAA, treatment will include oil-water separation via CPI (Corrugated Plate Interceptor), and DAF (Dissolved Air Floatation) oil removal processes, and biological treatment for destruction of dissolved organics. At MAB, treatment will include oil-water separation via CPI and DAF, with biological treatment being provided by an existing MAB effluent treatment facility, which is currently being upgraded as part of a separate project (KNPC MAB Effluent Treatment Facility or ETF Revamp Project). The ETF is part of a separate

EIA process. The WWT facilities at MAB will also include incineration of oily sludge that is generated both at MAA and MAB.

Figures 12A and 12B provide overall block flow diagrams of the two CFP WWT plants for the CFP at MAA and MAB refineries respectively. The CFP WWT plants have significant similarities and include:

- Wastewater collection and storage in the AOC and ODS systems
- OSBL and Roadway storm water collection and drainage system discharging to the Gulf via oil catchers (for MAB) and to existing concrete lined ditch along MAA south side (for MAA).
- Oil and suspended solids removal with Corrugated Plate Interceptor (CPI) and Dissolved Air Flotation (DAF) units
- Hydrogen Sulfide removal by aeration (a new CFP unit is provided at MAA; treatment is provided by the revamped KNPC MAB ETF at MAB)
- Biological Activated Sludge Treatment (BIOX) with Nitrification/Denitrification steps for destruction of soluble organics and removal of Nitrogen, and Activated Sludge removal by clarification (a new CFP unit is provided at MAA; treatment is provided by the revamped KNPC MAB ETF at MAB)
- An Observation Basin at MAA for retention and analyzing treated effluent and clean water before discharge to the Gulf.
- Mixing Basin (existing) at MAB for mixing, retention and analyzing treated effluent and clean water before discharge to the Gulf. Some treated effluent from the existing revamped ETF facilities will be diverted to an observation basin (part of the new WWT Unit 156) for reuse in meeting utility water demands.
- Waste Activated Sludge and Oily Sludge Dewatering and Deoiling by centrifuges to obtain biosludge suitable for disposal by National Cleaning Company (NCC) and oily sludge for incineration in the MAB Oily Sludge Incinerator.
- A new wastewater outfall pipeline will be provided for the treated CFP wastewater effluent generated at MAA which will extend outward from the coastline along the New Oil Pier a distance of 500 meters from the low mean water mark for subsurface discharge. No dredging is required because the outfall will adjoin the new oil pier. CFP wastewater at MAB will be routed to the revamp of the Effluent Treatment Facility (ETF project, by others) for biological treatment and then discharged to the existing Treated and Clean Water Mixing Basin.
- Chemical Feed Systems
- Sanitary and gray wastewater at MAA will be pumped offsite for treatment at an existing Municipal Waste Treatment Facility. Sanitary and gray wastewater at MAB will be treated in the new CFP Sanitary Wastewater Treatment Plant at MAB.

This project will implement technologies and operating practices to achieve water conservation and effluent reduction. Toward this intent, KNPC will endeavour to reduce wastewater generation and recycle/reuse all treated wastewater to the extent practical. Potential uses include:

- Treated sanitary effluent as irrigation water for landscaping at MAB Refinery,
- Wash down water, and
- Fire water make-up.

The CFP WWT Systems at the MAA and MAB refineries will be designed for continuous operation. The concept of multiple trains will be used to provide suitable system flexibility. This allows for outages of any individual piece of equipment without a complete shutdown of the WWT System or violation of the applicable discharge standards (at reduced throughput).

Wastewater from the SHU Refinery is currently treated within the refinery prior to being discharged. Post-CFP, wastewater generated from SHU will significantly decrease in conjunction with the retirement of the process units. SHU tank farm wastewater will be routed to the CFP WWT facilities at MAB.

Figure 12A MAA Refinery Wastewater Treatment System Overall Block Flow Diagram (PRELIMINARY)

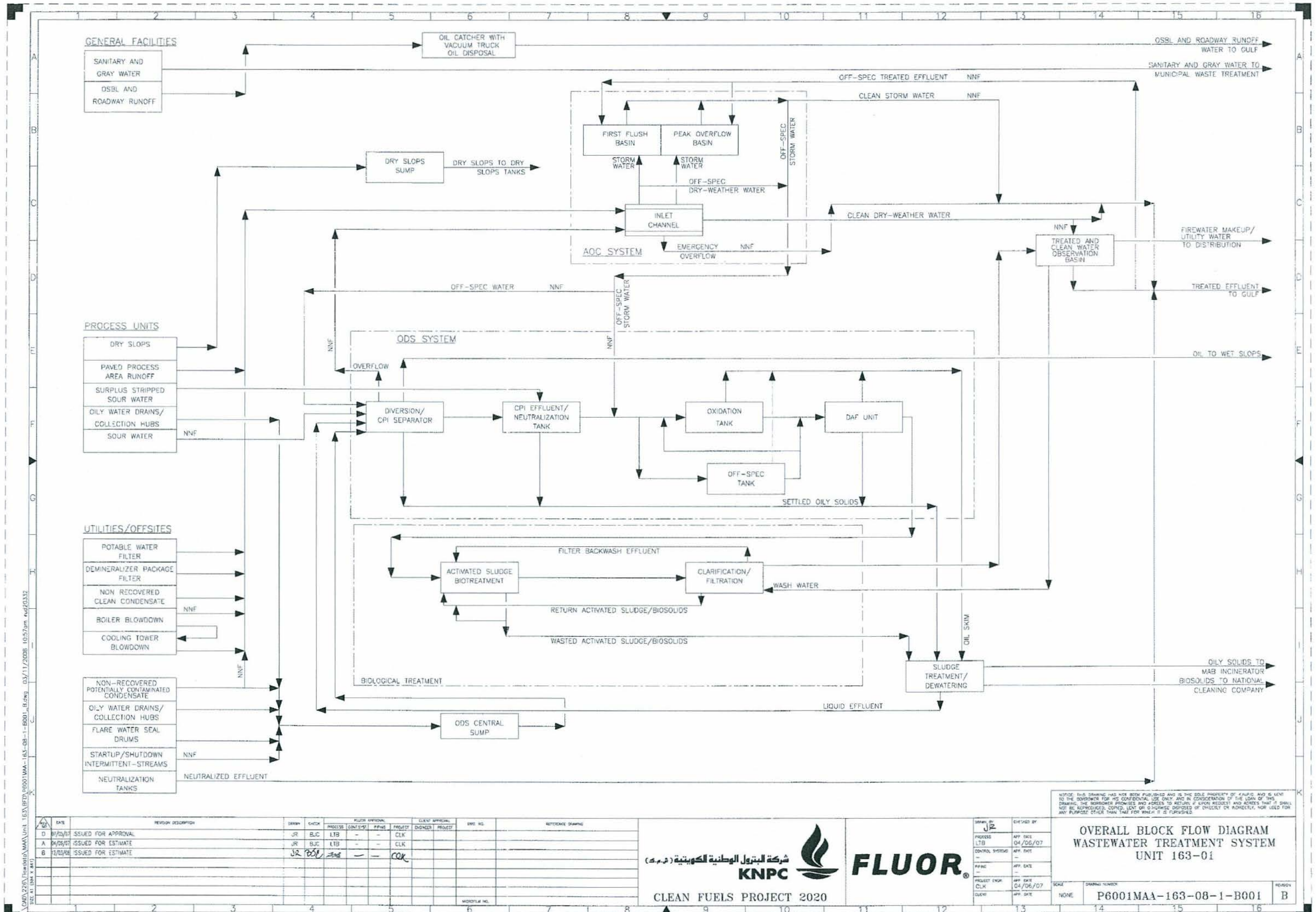
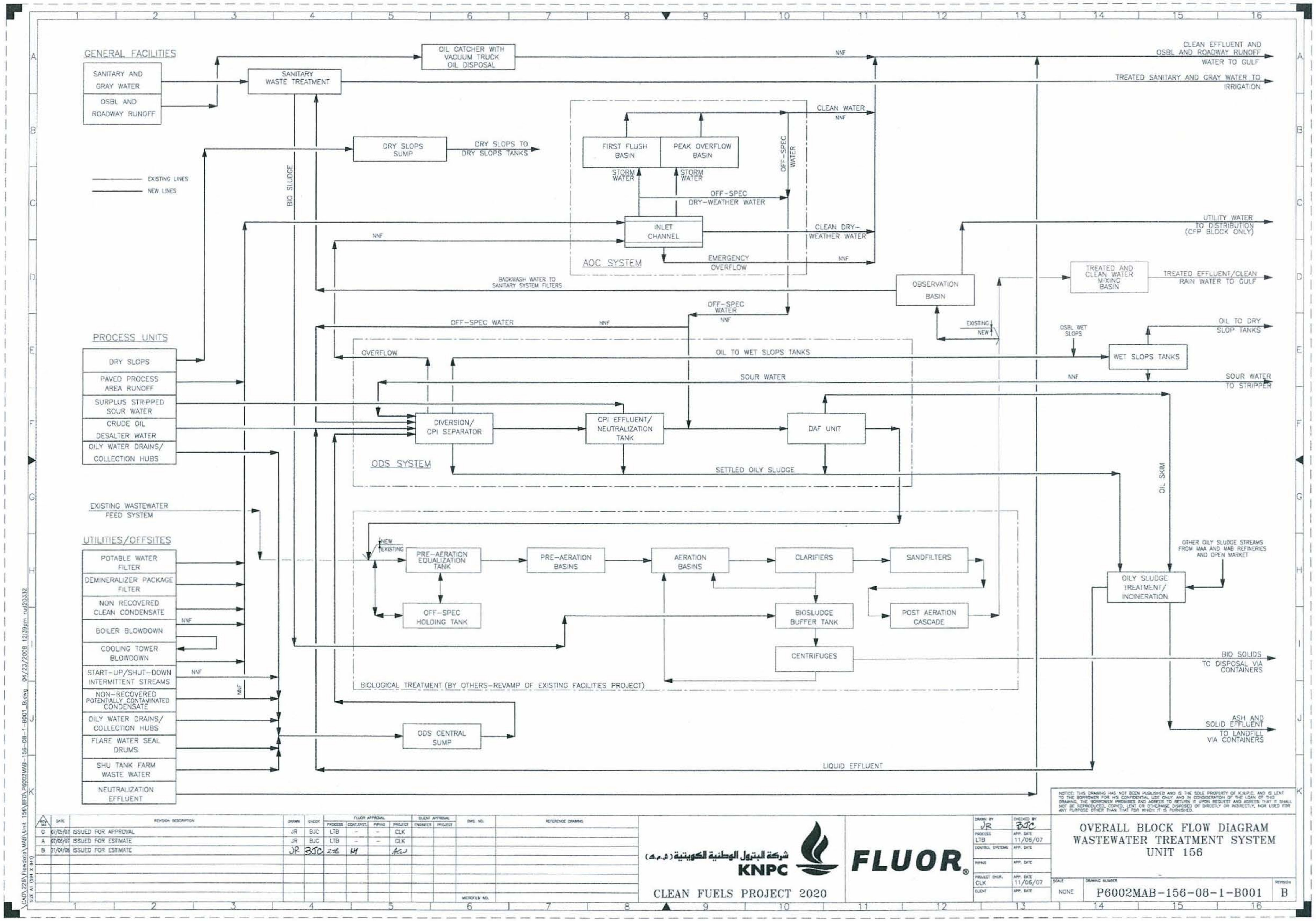


Figure 12B – MAB Refinery Wastewater Treatment System Overall Block Flow Diagram (PRELIMINARY)



12.3.2 Safeguarding against Uncontrolled Discharges

The CFP's wastewater treatment system will incorporate a system of relief devices and instrumentation safeguards to provide against uncontrolled loss of containment. A set of 'Process Safeguarding Flow Schemes' detailing such instrumentation will be included in the wastewater treatment system Operating Manuals.

12.3.3 Specific Wastewater Streams and Treatment

The new and revamped CFP facilities will generate a variety of liquid streams that are generated both continuously and intermittently. Table 12.1 (below) shows the separate industrial effluent drainage systems installed and the sludge collection/treatment system provided.

Table 12.1: Wastewater classifications

Treatment System	Feed Sources
Accidentally Oil Contaminated (AOC) System	• Paved Process Area Storm Water Runoff • Cooling Tower Blowdown • Firewater from all Paved Process Areas • Boiler Blowdown (normally via Cooling Tower Blowdown) • Potable Water Filter • Demineralizer Package Filter • Non-Recovered Clean Condensate
Oil Drips System (ODS)	• Surplus Stripped Sour Water (segregated routing by separate piping) • Crude Oil Desalter Water (MAB Refinery only) • Rotating Equipment Drip Pans • Process Area Collection Hubs • Oily Drains During Equipment Maintenance, Shutdowns and Start-ups • Flare Water Seal Drum Overflows • Non-Recovered Potentially Contaminated Condensate • Off-spec AOC Wastewater
Dry Slops System	• Hydrocarbon Sample Discharge • Collection Hubs and Rotating Equipment Base Plates • Off-Spec Products • Water-Free Oily Drains During Shutdowns / Start-ups
OSBL and Roadway Storm Water Drainage	• Storm water from outside paved process and roadway areas
Sanitary and Grey Wastewater System	• Most permanent buildings (administration, control room, maintenance, shelters, smoking areas, etc.)
Sludge Collection and Treatment System	• Corrugated Plate Interceptor System • CPI Effluent / Neutralization Tank • Dissolved Air Floatation Units • Biological Treatment Clarifier (MAA Refinery only) • Vacuum Trucks

General Note: Sample line open discharges will be diverted into the most suitable and cost effective drainage system without causing adverse impact on the environment and / or WWT System performance.

Focusing on each of these seven wastewater streams, the specific collection and treatment characteristics are as follows:

a) Accidentally Oil Contaminated (AOC) sewer system

The AOC system is an underground gravity flow system that collects normally oil-free and pH-neutral wastewater streams from within and around the individual units, fire fighting water, rainfall runoff from paved process surface areas, and utility systems wastewater streams (i.e. continuous cooling tower and continuous/intermittent boiler blowdown, potable water and demineralizer package filter discharge, non-recovered clean condensate). Continuous/intermittent boiler blowdown is normally routed to the cooling tower basin and it ends up in the AOC system as cooling tower blowdown. Alternate provision also exists for continuous/intermittent boiler blowdown to go directly to the AOC system.

The system is equipped with dry weather flow (DWF; no storm and/or fire event water runoff) pumps with an oil-water analyzer specifically to monitor for any oil accidentally present into the above mentioned streams. Should sampling and analysis of the AOC DWF indicate that it contains unacceptable levels of hydrocarbons, flow will be automatically routed to the appropriate treatment system.

AOC-category wastewater is routed through the AOC drainage network to a controlled discharge facility that consists of Inlet Channel designed for dry weather flows, First Flush basin designed for the "first rain" water runoff, and Peak Overflow basin designed for rainfall after the first flush. Should the AOC influent flow exceed the dry weather pumping capacity of the Inlet Channel (i.e. during a storm or fire event), then water is passively diverted into these impounding basins by sequentially overflowing a set of weirs located between the Inlet Channel and the basins. Impounded water is evaluated for contamination and, if needed, transferred to the appropriate treatment system prior to discharge. Should the AOC dry weather wastewater contain unacceptable levels of hydrocarbons, it is diverted to the Oily Drips System (ODS) facilities for treatment.

b) Oil Drips System (ODS) Drainage and Biological Treatment System

The ODS is an underground gravity flow system that collects and treats wastewater streams contaminated with oil and organics that require removal of oil with Corrugated Plate Interceptor (CPI) and Dissolved Air Flotation (DAF) oil separators and organics via biological treatment (a new biological treatment system will be provided for CFP effluents at MAA; biological treatment for CFP effluents at MAB will be via the revamped KNPC MAB ETF).

The main streams segregated and collected in this system are: non-recovered potentially contaminated condensate, oily wastewater from rotating equipment drip pans, collection hubs, and sampling points, oily drains during equipment/unit shutdowns, and continuous flare seal water blowdown. They are collected in a central sump located within the CFP WWT Units at MAA and MAB. Surplus stripped sour water comes through a separate pipeline directly into the CPI Effluent/Neutralization Tank.

The ODS facilities at the MAA Refinery will consist of free oil removal in CPI separator, followed by neutralization and H_2S oxidation, then emulsified oil removal in parallel DAF separators, biological treatment, clarification, and effluent filtration. Treated effluent is pumped to the Observation Basin and then to the Gulf via an above-ground pipe. Oily solids and waste activated sludge generated in the ODS facilities are sent to the sludge collection/treatment system where they are centrifuged to remove water and oil. Free oil removed in the CPI separators is transferred to the Wet Slops System (Unit 163-Circuit 02) for oil recovery. Oily effluent from the DAF separators has its entrained solids removed in the Sludge Treatment/Dewatering facilities. The liquid effluent will be recycled to the CPI separators. The oily solids will be routed to the new oily sludge treatment / incineration system at MAB. Bio-solids will be sent for offsite treatment and disposal by NCC.

The ODS facilities at the MAB Refinery will consist of free oil removal in parallel CPI separators, followed by neutralization, then emulsified oil removal in parallel DAF separators. The DAF effluent will then be routed to the existing Biological Activated Sludge Treatment (BIOX) system at MAB (which is being provided by a separate ETF revamp project). The BIOX system will provide H_2S removal by oxidation to dissolved sulfate in a pre-aeration section, a biological activated sludge system, clarification and effluent filtration. Treated BIOX effluent will be routed to the Observation Basin, to be used as CFP utilities water as needed. Any remaining portion of the treated effluent will be commingled with other plant effluent in the existing Mixing Basin and then discharged to the Gulf via the existing discharge arrangements.

Oily solids from the CFP and DAF oil separators in the CFP ODS System will be routed to the oily sludge centrifuges for dewatering, and the resulting dewatered cake will be incinerated in a fluidized bed incinerator. This incinerator will be designed with adequate capacity to also incinerate oily sludge streams from the rest of the MAB Refinery, MAA Refinery and open market.

Biological solids will be centrifuged in the existing ETF dewatering system, and then shipped to NCC for disposal. Free oil removed in the CFP separators will be transferred to the wet slops system for oil recovery.

c) Dry Slops System (DS)

The Dry Slops System collects, in a hard-piped gravity flow network, hydrocarbon streams free of water from various equipment drains, rotating equipment drip pans and sampling points located in Hydrocarbon Process, Hydrocarbon Support and Utility units. The network is connected to an underground DS sump along with the ODS sump. The water-free oil collected in the DS sump is pumped to the dry slops tanks.

d) OBSL & Roadway Drainage System

This system collects storm water from outside the paved and diked process areas in drainage systems routed directly to the Gulf via oil catchers as a matter of additional precaution and protection of the environment. Oil separated in the oil catcher is removed and transported via vacuum trucks. Clean CFP OSBL storm water will discharge to the Gulf via new above and below ground pipes at MAA at the edge of Gulf waters. Clean CFP OSBL storm water at MAB will be routed to an existing ditch that discharges to the Gulf.

e) Sanitary and Gray Water Collection System

Sanitary wastewater for CFP will be collected from buildings and routed to sanitary lift stations by gravity flow. Sanitary and gray wastewater is then pumped through sewer systems to:

- Municipal Waste Treatment facility located outside refineries (for MAA).
- A dedicated Activated Sludge Biological Treatment unit (for MAB). Treated effluent from this unit will be used for irrigation. Waste activated sludge will be sent to the Biological Sludge Handling Facility, which is part of a separate KNPC ETF project.

f) Sludge Collection and Treatment System

The sludge collection and treatment system collects and stores sludge from the various pieces of WWT equipment. These various sludge streams are classified into either:

1. Waste activated sludge from biological treatment, or
2. Oily solids from the CPI and DAF oil-separating units.

As previously described, for the MAB Refinery, biological treatment of wastewater from the CFP block will be carried out in the ETF facilities provided by a separate KNPC project. Waste activated sludge resulting from this treatment will be dewatered in the Sludge Dewatering facility which is also a part of the ETF system, and then shipped off-site to the NCC for disposal. Oily solids from the CPI and DAF separators, after removal of oil and water by centrifuging, will be routed to the new CFP oily sludge incineration system at MAB.

At MAA, the collected sludges are transferred appropriately into segregated storage tanks. The oily sludge collection systems will also be equipped with a vacuum truck disposal connection. The contents of each storage tank are treated in separate centrifuges to remove water and oil. The 25% solid content cakes generated by the centrifuges are loaded in roll-off boxes and transported to the appropriate sludge treatment and disposal facilities (i.e. biological sludge shipped to NCC and oily sludge routed to MAB oily sludge incinerator). Liquid recovered from oily sludge centrifuges will be returned to the front end of the ODS system.

After dewatering, the oily sludge cake created at both MAB and MAA WWT facilities will be routed to a new CFP fluidized bed incinerator located at the MAB Refinery. The estimated quantities are as follows:

Table 12.2: Oily Sludge Quantities

Oily sludge	m3/yr
Local Marketing	500
MAA Existing Sludge	4,000
MAA CFP Sludge	2,370
MAB Existing Sludge	1,500
MAB CFP Sludge	14,410

The fluidized sludge incinerator will operate two shifts per day. Incinerator ash will be disposed in local landfills.

The biological sludge cakes from both refineries will be transported off-site for disposal by the NCC. Approximately 13,650 m^3/yr of biological sludge will be produced by the process wastewater treatment plant in MAA.

Excess biosludge from the new MAB CFP sanitary wastewater treatment system will be sent to the existing MAB ETF revamp to be combined and disposed of (by NCC) with the existing biosludge that is generated.

12.3.4 Sour Water Stripping Unit (SWSU)

Sour water streams from the CFP process units at the MAA and MAB refineries will be segregated from other industrial wastewater streams. New sour water treating facilities will be provided at both refineries to remove (i.e. "strip off") impurities such as H_2S, NH_3 and hydrocarbons. The overhead stream from these treatment units will be routed back to new sulphur recovery facilities.

At the MAA Refinery, the stripped effluent from the SWSU will be routed to the Delayed Coking Unit (Unit 136) for coke cutting and coke drum cooling with the balance sent for wastewater treatment.

At the MAB Refinery, the stripped effluent from the SWSU will be routed to the Crude Unit Desalter (Units 11/111), ARDS, Hydrotreaters and the balance sent to wastewater treatment.

12.3.5 Cooling Water System

The Cooling Water System at both the MAA and MAB refineries (Unit 175 & Unit 132, respectively) will be a closed-circuit fresh water system. The new facilities at each refinery will include a cooling tower, cooling water pumps, and steam turbine drivers.

Cooling tower blowdown will be piped to the AOC Drain System. Makeup water will be from desalinated water, supplied by MEW, and/or fresh water.