6-3-3 Airports

An airport is also quite important to accept relief aid / goods and rescue support from abroad. Hence, the destruction of the airport should be prevented as much as possible.

(1) Damage Function

In some past earthquakes in other places, airports have been closed for several days due to cracks in the runway, damage to control towers or collapse of the landing support system.

Airport damage for the scenario earthquake is estimated from the relationship between damage experienced and earthquake motion (PGA).

The recent earthquake damage to the airport is summarized in Table 6-20.

Table 6-20 Records of Damage to Airports due to Earthquakes

Earthquake	Airport	Damage Grade	Damage	Observed or Estimated Acceleration
1989 Loma Prieta Earthquake (USA)	San Francisco Airport (International)	1	- Hairline runway cracks - Non-structural damage to the terminal - Ceilings fell in the control tower - Windowpanes in the control tower shattered - Airport was closed for 13 hours	323 gal
1993 Kushiro-oki Earthquake (Japan)	Kushiro Airport (International)	1	- Minor cracks in slopes	520 gal
1993 Hokkaido Nansei-oki Earthquake (Japan)	Okushiri Airport (Commuter)	2	- 20 m crack in runway - Airport was closed for 4 days - Damage to landing guide lights	392 gal
1995 Kobe Earthquake (Japan)	Kansai Airport (International)	0	- No damage	169 gal
2000 Tottori-ken Seibu Earthquake (Japan)	Yonago Airport (Local)	2	- Cracks in the runway - Airport was closed for 5 days	546 gal
2001 Geiyo Earthquake (Japan)	Hiroshima Airport (Local)	0	- No damage	298 gal
	Nishi Hiroshima Airport (Commuter)	1	- Minor damage	298 gal
	Matsuyama Airport (Local)	1	- Minor damage	298 gal
2001 Seattle Earthquake (USA)	Seattle Seatac Airport (International)	1	- Damage to control tower	194 gal
	King County Airport (in Bowing factory)	2	- Major cracks in the runway	267 gal

Note
Damage Grade 0 : No Damage
Damage Grade 1 : Minor Damage, Airport will not be closed more than 1 day
Damage Grade 2 : Major Damage, Airport will be closed for several days

Thus, an airport may be closed for several days if the PGA is greater than 300 gal (= 0.3g). Here, the airport damage function is defined as in Table 6-21.

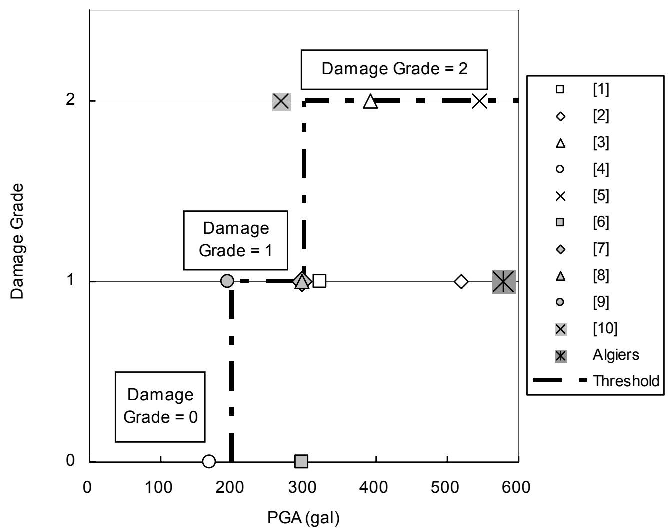
Table 6-21 Relationship between Damage Grade and Peak Ground Acceleration

PGA (gal)	0 to 200	200 to 300	more than 300
Damage Grade	0	1	2

(2) Verification of Damage Function

In the Boumerdes Earthquake, Algiers airport, where the PGA was estimated around 578 gal (it was observed in the neighborhood seismic observatory), suffered slight damage such as clacks occurring in walls / columns in the terminal, control tower, hangar and so on. However, the airport operated continuously after the earthquake. Hence, the damage grade is judged as 1.

For the relationship between the damage grade and the PGA refer to Table 6-21. The Algiers airport damaged experience from the Boumerdes Earthquake is shown in Figure 6-34.



(The number in the legend of the above figure corresponds with the airport name in Table 6-20.)

Figure 6-34 Relationship between Damage Grade of Airport and PGA

Damage condition (grade) of the Algiers airport from the Boumerdes Earthquake deviates from the threshold line. However, the structure of the Algiers port is based on the international code, this implies that there is possibility that similar damage could occur due to a huge earthquake. Hence, the above relationship is applied for the airport damage estimation to be on the safe side.

(3) Result and Discussion

Figure 6-35 shows the result of the airport damage estimation.

PGA in the Zemmouri case was greater than the Khair al Din case due to the positional relation between the airport and those active faults (the Zemmouri fault is the nearer to the airport than the Khair al Din fault). Damage is estimated to be the same grade (damage grade 2, the airport will be closed for a few days), however, it is expected that the Zemmouri case will affect the airport more adversely than the Khair al Din case due to the difference of the PGA.

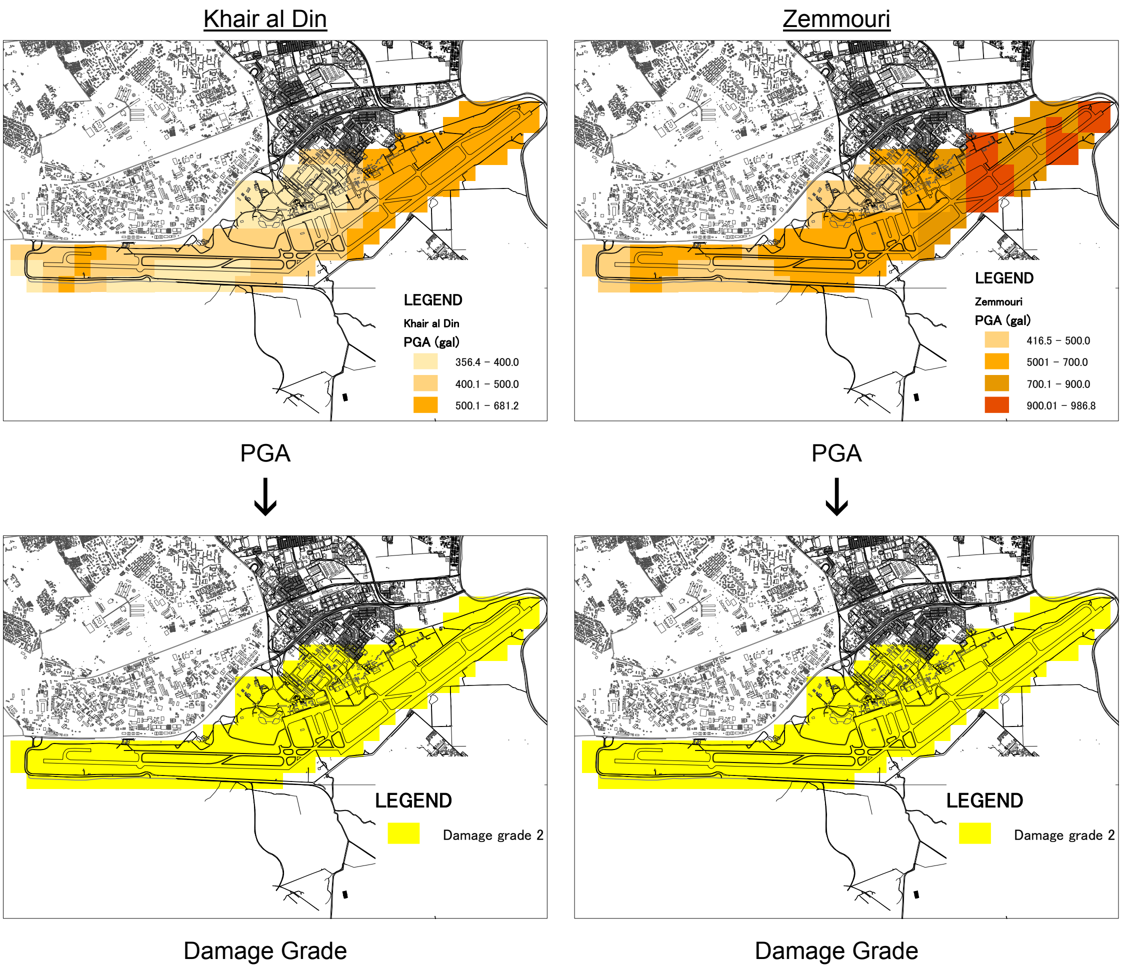


Figure 6-35 Result of Airport Damage Estimation

6-3-4 Water Supply

(1) Water Supply Pipelines

1) Damage Function

In general, the empirical approach for estimation of damage to water supply pipelines is adopted as the suitable method for a seismic microzonation study. The estimation of the damage ratio utilizes several parameters, such as pipe materials, diameter, ground motion at the site and so on.

The basic concept of the damage function for pipelines buried underground was established by Kubo and Katayama (1975) based on the damage condition of the pipelines due to the San Fernando Earthquake in 1971 as shown in Figure 6-36.

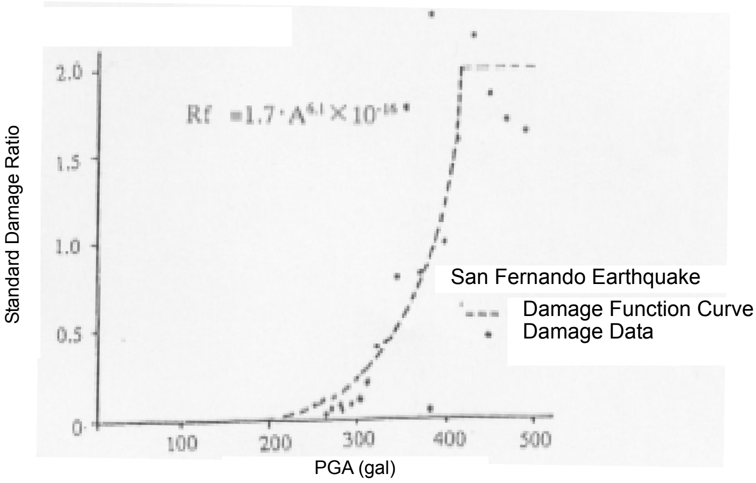


Figure 6-36 Relationship between Peak Ground Acceleration and Standard Damage Ratio for buried Pipeline based on the San Fernando Earthquake (1971)

Afterward, many researchers / institutions have examined / modified the above mentioned standard ratio with a coefficient for the pipe materials / diameter and ground type / liquefaction potential. The Kobe Earthquake in 1995 is one of the best-known damage examples and the relationship between damage conditions and seismic motion has been extensively studied. Since the Kobe Earthquake, each prefecture and some cities in Japan have conducted microzoning studies. Several dozen damage functions, especially the coefficients, have been applied for the studies. In this study, the applied damage functions were examined with the counterpart, and then mean values of the coefficients were applied as follows:

$R_{fm} = R_f * C_g * C_p * C_d$

where

R_{fm} : Damage ratio (points/km)

R_f : Standard damage ratio (points/km)

$R_f = 1.7 * A^{6.1} * 10^{-16}$ ---------- (maximum $R_f = 2.0$)

A : Peak ground acceleration (gal)

C_g : Modification coefficient for ground type with liquefaction potential

Ground Type	P_L	C_g
Hill/Plateau	-	0.50
Alluvial Plain	P_L=0	1.00
Soft Ground	$0<P_L\leq5$	2.00
	$5<P_L\leq15$	2.90
	$15<P_L$	4.70

C_p : Modification coefficient for pipeline material

C_d : Modification coefficient for pipeline diameter

Pipe Material \ Pipe Diameter		ϕ ≤75mm	75mm< ϕ ≤150mm	150mm< ϕ ≤250mm	250mm< ϕ ≤450mm	450mm< ϕ ≤1,000mm	1,000mm< ϕ
AC, AMC	Asbestos Cement	6.40	3.40	2.40	2.00	1.40	0.60
AG	Galvanized Steel	2.70	1.70	1.10	1.00	0.90	0.40
B	Concrete	2.00	1.50	0.90	0.50	0.40	0.20
BPAT	Precast Concrete	0.13	0.10	0.07	0.05	0.03	0.02
F	Cast Iron	1.70	1.30	1.00	0.60	0.40	0.20
FD	Ductile Cast Iron	0.70	0.40	0.20	0.10	0.08	0.05
FG	Gray Cast Iron	4.60	2.60	1.80	1.50	1.20	0.50
PEHD	Polyethylene	0.20	0.15	0.10	0.07	0.04	0.02
PVC	PVC Pipe	2.10	1.40	1.00	0.80	0.60	0.30

Note: When the material or the diameter were unknown, the coefficient of galvanized steel or ϕ 75 mm were applied, respectively. When both the material and diameter were unknown, the coefficient of galvanized steel – ϕ 75mm (2.70) was applied.

Figure 6-37 shows the applied damage function curves according to the above mentioned equation and coefficients.

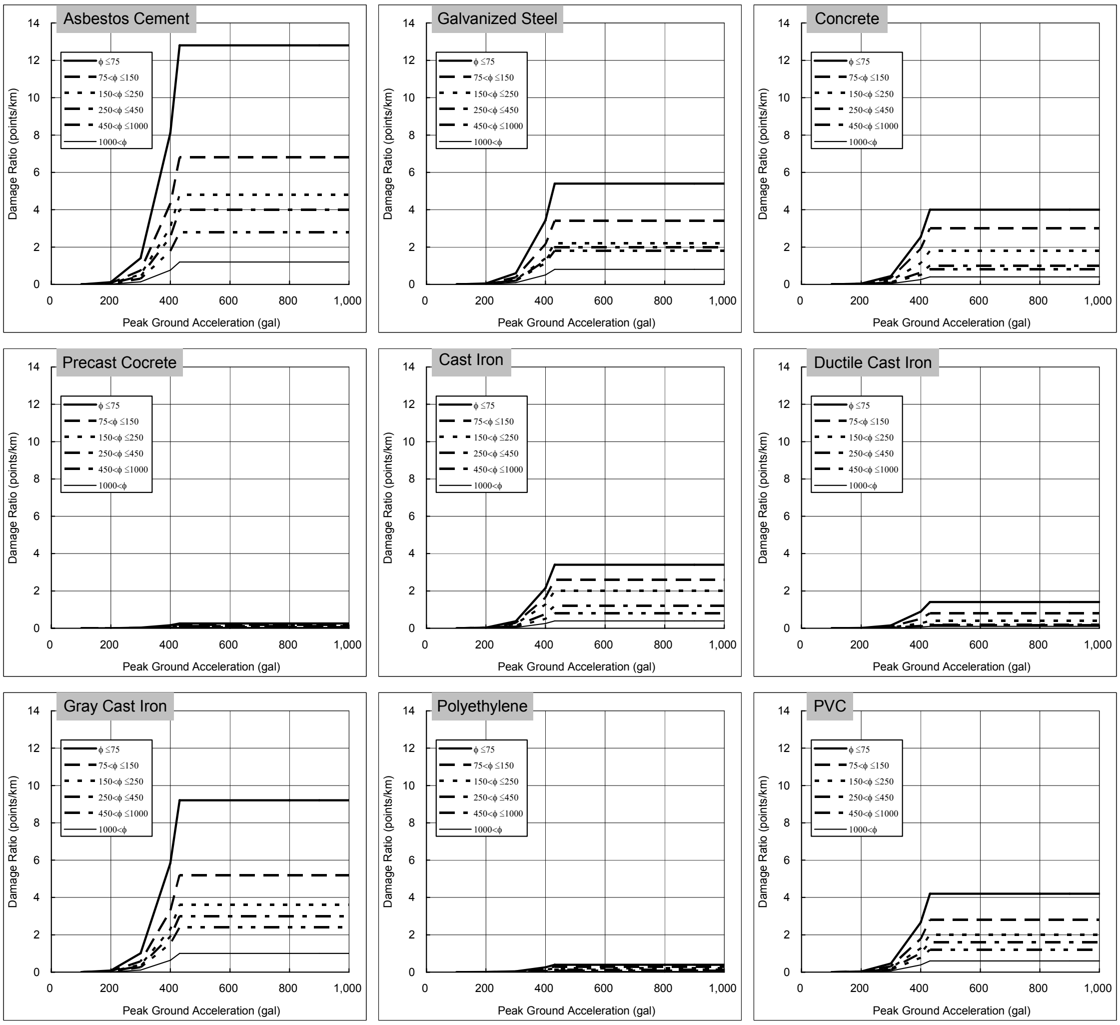


Figure 6-37 Damage Function Curve for Water Supply Pipeline by each Material

2) Result and Discussion

As a result, the number of damage points in each 250 m grid was calculated by the damage ratio multiplied by the total length of the pipelines.

Figure 6-38 to Figure 6-39 shows the result of the damage estimation for the water supply pipeline by 250 m grid sectors. The damage points will concentrate in the central part of the study area and / or along the coastline for the Khair al Din case and in the eastern part of the study area for the Zemmouri case.

Table 6-22 and Table 6-23 shows the tabulation of damage points by commune and by combination of pipe material and diameter, respectively.

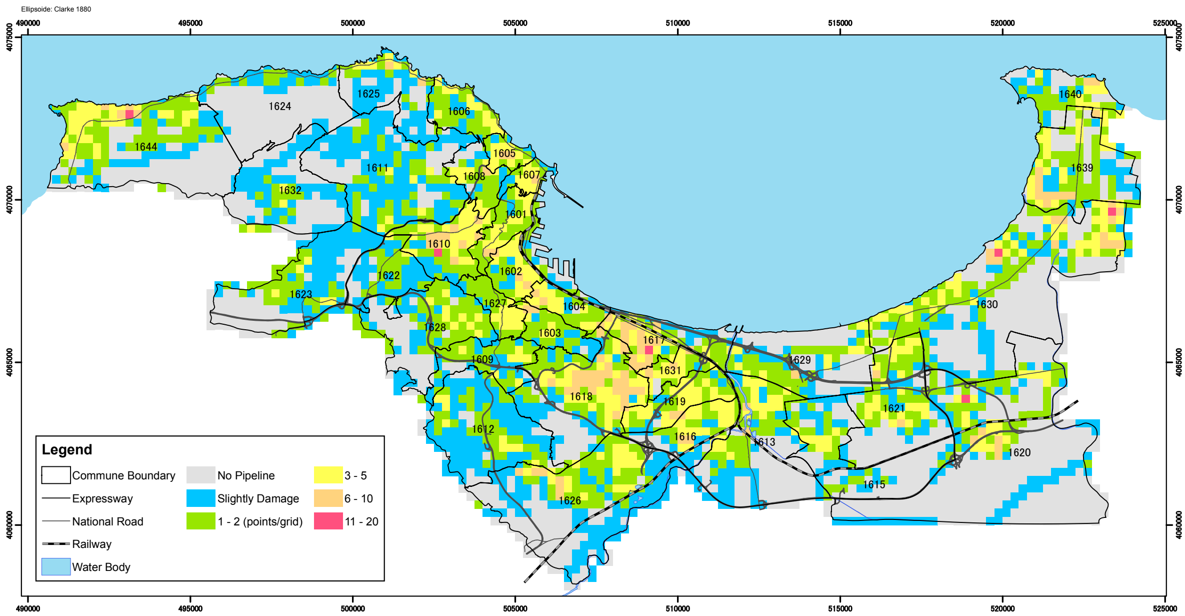


Figure 6-38 Damage Points of Water Supply Pipeline: Khair al Din

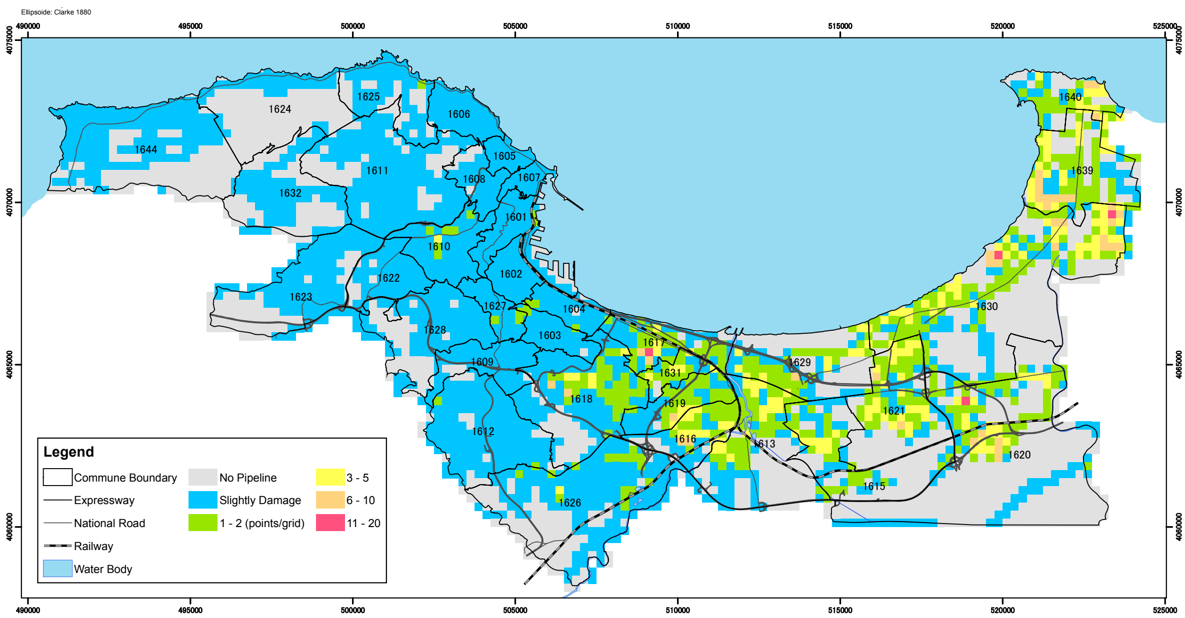
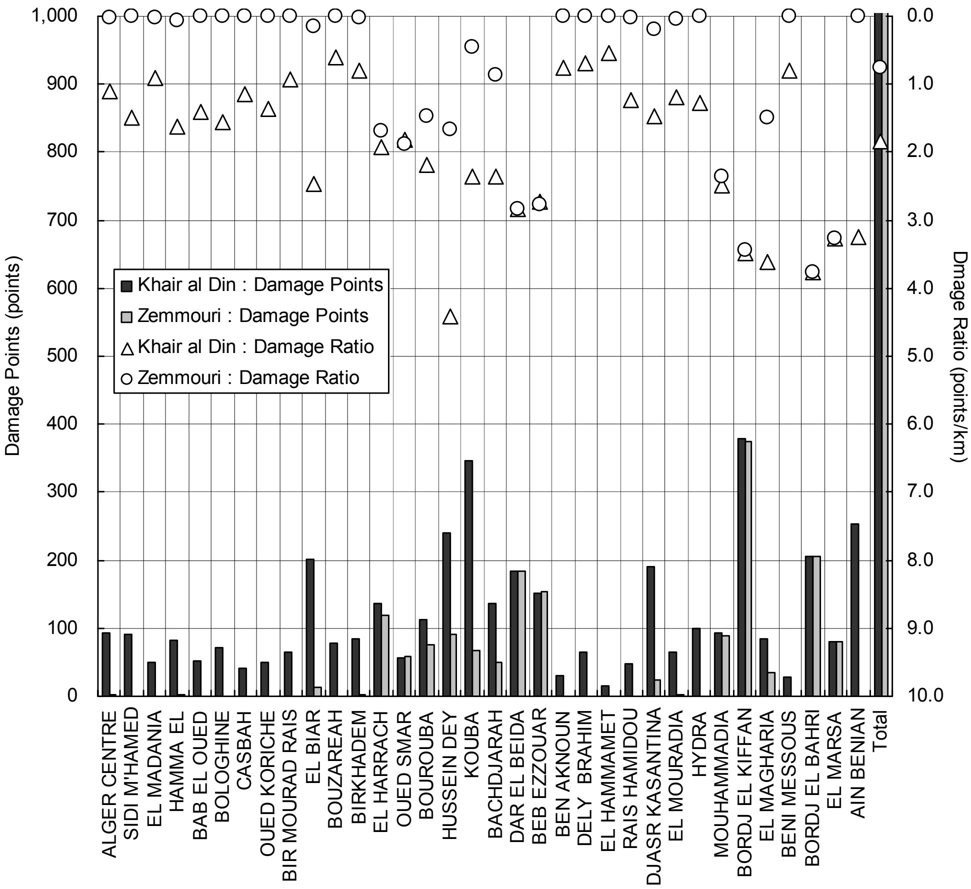


Figure 6-39 Damage Points of Water Supply Pipeline: Zemmouri

Table 6-22 Summary of Damage Points to the Water Supply Pipeline by Commune

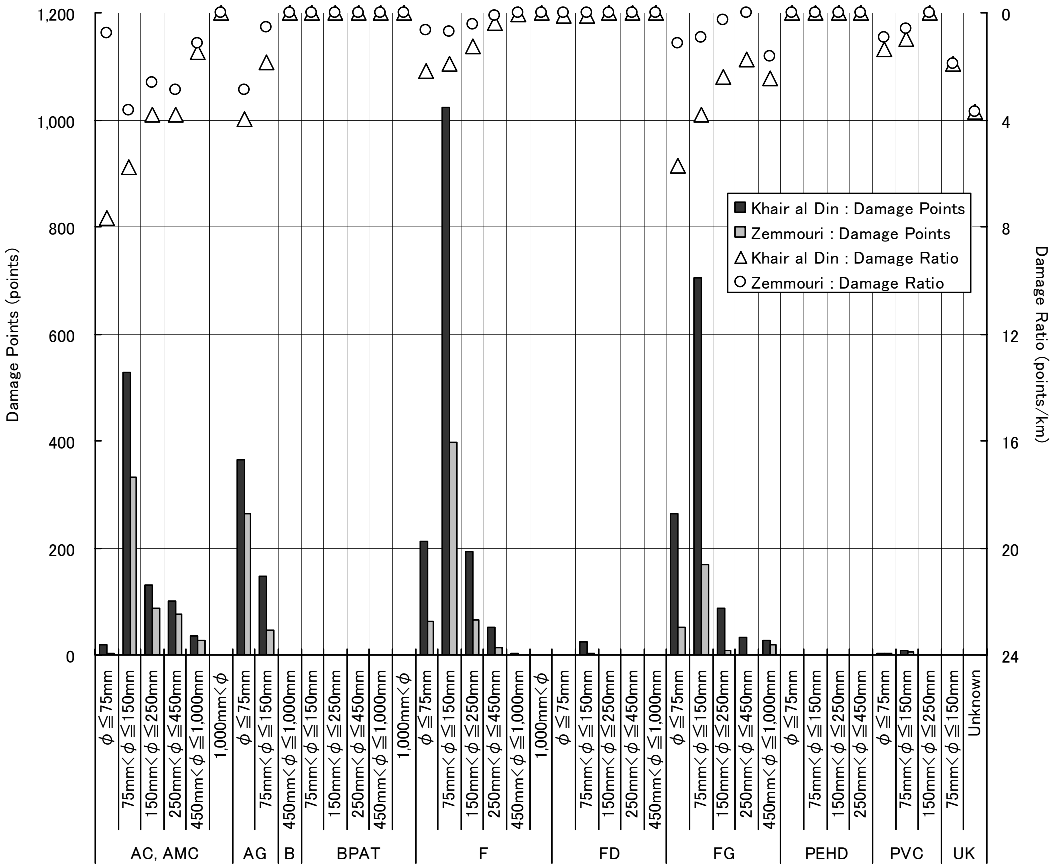
Commune	Length (km)	Khair al Din		Zemmouri	
		Damage Points	Damage Ratio (points/km)	Damage Points	Damage Ratio (points/km)
ALGER CENTRE	83.6	92	1.10	2	0.02
SIDI M'HAMED	61.2	91	1.49	0	0.00
EL MADANIA	55.1	50	0.91	1	0.02
HAMMA EL ANNASSER	50.4	82	1.63	3	0.06
BAB EL OUED	37.9	53	1.40	0	0.00
BOLOGHINE IBNOU ZIRI	45.8	71	1.55	0	0.00
CASBAH	36.7	42	1.14	0	0.00
OUED KORICHE	36.7	50	1.36	0	0.00
BIR MOURAD RAIS	69.0	65	0.94	0	0.00
EL BIAR	81.7	202	2.47	13	0.16
BOUZAREAH	126	77	0.61	0	0.00
BIRKHADEM	103.3	84	0.81	2	0.02
EL HARRACH	70.8	136	1.92	120	1.69
OUED SMAR	31.4	57	1.82	59	1.88
BOUROUBA	51.7	113	2.19	76	1.47
HUSSEIN DEY	54.5	241	4.42	91	1.67
KOUBA	147.5	347	2.35	68	0.46
BACHDJARAH	58.1	137	2.36	50	0.86
DAR EL BEIDA	65.1	184	2.83	185	2.84
BEB EZZOUAR	55.5	151	2.72	154	2.77
BEN AKNOUN	41.0	31	0.76	0	0.00
DELY BRAHIM	92.0	64	0.70	0	0.00
EL HAMMAMET	29.1	16	0.55	0	0.00
RAIS HAMIDOU	38.8	48	1.24	1	0.03
DJASR KASANTINA	129.1	191	1.48	24	0.19
EL MOURADIA	55.3	66	1.19	3	0.05
HYDRA	77.8	99	1.27	0	0.00
MOUHAMMADIA	37.8	94	2.49	89	2.35
BORDJ EL KIFFAN	108.5	378	3.48	374	3.45
EL MAGHARIA	23.3	84	3.61	35	1.50
BENI MESSOUS	36.0	29	0.81	0	0.00
BORDJ EL BAHRI	54.7	206	3.77	206	3.77
EL MARSA	24.5	80	3.27	80	3.27
AIN BENIAN	78.3	254	3.24	0	0.00
Total	2,148.2	3,965	1.85	1,636	0.76



As far as the locality feature of the result is concerned, the commune that is estimated to generate the most damage points, and the highest damage ratio (points/km) will be Bordj El Kiffan for both cases (Khair al Din and Zemmouri), and Hussein Dey for the Khair al Din case and Bordj El Bahri for Zemmouri case, respectively.

Table 6-23 Summary of Damage Points to the Water Supply Pipeline by Pipe Material - Diameter

Material	Diameter	Length (km)	Khair al Din		Zemmouri	
			Damage Points	Damage Ratio (points/km)	Damage Points	Damage Ratio (points/km)
Ac, AMC: Asbestos Cement	ϕ ≤ 75mm	2.6	20	7.69	2	0.77
	75mm < ϕ ≤ 150mm	91.73	528	5.76	332	3.62
	150mm < ϕ ≤ 250mm	33.96	130	3.83	88	2.59
	250mm < ϕ ≤ 450mm	26.77	102	3.81	77	2.88
	450mm < ϕ ≤ 1,000mm	23.53	35	1.49	27	1.15
	1,000mm < ϕ	9.23	0	0.00	0	0.00
	1,000mm < ϕ	1.02	0	0.00	0	0.00
AG: Galvanized Steel	ϕ ≤ 75mm	91.84	364	3.96	265	2.89
	75mm < ϕ ≤ 150mm	79.63	146	1.83	45	0.57
B: Concrete	450mm < ϕ ≤ 1,000mm	0.01	0	0.00	0	0.00
BPAT Precast Concrete	75mm < ϕ ≤ 150mm	2.77	0	0.00	0	0.00
	150mm < ϕ ≤ 250mm	23.95	0	0.00	0	0.00
	250mm < ϕ ≤ 450mm	34.94	0	0.00	0	0.00
	450mm < ϕ ≤ 1,000mm	91.81	0	0.00	0	0.00
	1,000mm < ϕ	64.74	0	0.00	0	0.00
F: Cast Iron	ϕ ≤ 75mm	98	213	2.17	62	0.63
	75mm < ϕ ≤ 150mm	545.78	1,024	1.88	397	0.73
	150mm < ϕ ≤ 250mm	156.99	193	1.23	65	0.41
	250mm < ϕ ≤ 450mm	135.7	51	0.38	13	0.10
	450mm < ϕ ≤ 1,000mm	41.1	2	0.05	1	0.02
FD: Ductile Cast Iron	ϕ ≤ 75mm	7.91	1	0.13	0	0.00
	75mm < ϕ ≤ 150mm	179.37	24	0.13	4	0.02
	150mm < ϕ ≤ 250mm	44.12	0	0.00	0	0.00
	250mm < ϕ ≤ 450mm	28.03	0	0.00	0	0.00
	450mm < ϕ ≤ 1,000mm	19.04	0	0.00	0	0.00
FG: Gray Cast Iron	ϕ ≤ 75mm	46.17	265	5.74	53	1.15
	75mm < ϕ ≤ 150mm	183.86	705	3.83	168	0.91
	150mm < ϕ ≤ 250mm	36.65	87	2.37	9	0.25
	250mm < ϕ ≤ 450mm	19.74	34	1.72	0	0.00
	450mm < ϕ ≤ 1,000mm	11.54	28	2.43	19	1.65
PEHD: Polyethylene	ϕ ≤ 75mm	1.36	0	0.00	0	0.00
	75mm < ϕ ≤ 150mm	0.15	0	0.00	0	0.00
	150mm < ϕ ≤ 250mm	1.21	0	0.00	0	0.00
	250mm < ϕ ≤ 450mm	1.72	0	0.00	0	0.00
PVC: Polyvinyl Chloride	ϕ ≤ 75mm	2.19	3	1.37	2	0.91
	75mm < ϕ ≤ 150mm	8.34	8	0.96	5	0.60
	150mm < ϕ ≤ 250mm	0.06	0	0.00	0	0.00
UK: Unknown	75mm < ϕ ≤ 150mm	0.52	1	1.92	1	1.92
	Unknown	0.27	1	3.70	1	3.70
Total		2,148.35	3,965	1.85	1,636	0.76



In this study area, the combination of cast iron - ϕ 75 mm to 150 mm is the longest, which means that the pipeline becomes increasingly likely to be located in a high seismicity or liquefaction prone area, and the coefficient is relatively high. As a result, it is estimated that this pipeline will suffer the heaviest damage. Meanwhile, the combination of the ductile cast iron - ϕ 75 mm to 150 mm is the third longest, and the coefficient is low. As a result, the damage points are fewer.

Hence, the combination of the pipe material – diameter has a considerable impact on the estimated damage.

(2) Elevated Water Supply Tanks

A total of 23 elevated water supply tanks are located in the study area. The tanks are included in the water supply system for daily life in Wilaya of Algiers, their function is quite important. Hence, it is easily conceivable that heavy damage to the tanks will cause suffer ing and disruption to the lives of the quake survivors when a huge earthquake occurs.

Empirical approaches for the estimation of damage to the elevated water supply tanks are problematic because few reports exist regarding past damage. Hence, the vulnerability of the tanks for the scenario earthquake was evaluated qualitatively by overlaying the tank locations on a geo-hazard map that consists of the peak ground acceleration map (hereinafter referred to as “the PGA map”), the liquefaction potential map (hereinafter referred to as “the PL map”) and the slope failure risk map (here in after referred to as “the SR map”).

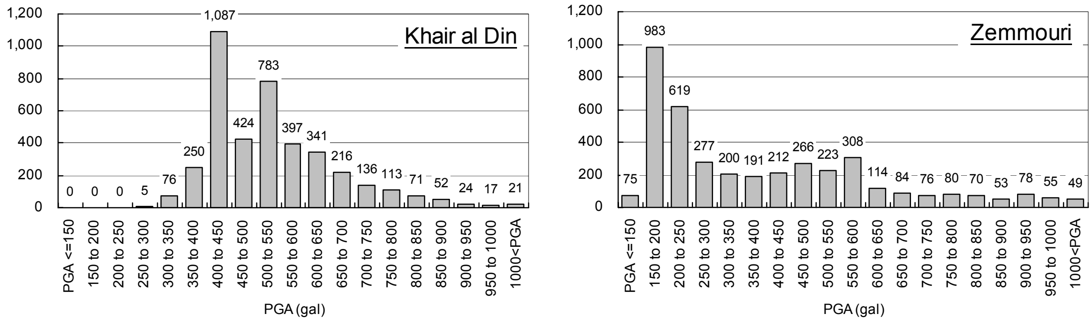
1) Method

The geo-hazard map for the damage evaluation consists of 2 maps (refer to Figure 6-40 and Figure 6-41) the first of which overlays the PL map on the PGA map and the second overlays the SR map on the PGA map. These show geological / geotechnical hazard risks, and "risk" is defined as a possibility of damage to facilities. The procedure for making the geo-hazard maps is as follows:

- 1st: PGA is given a score as shown in Table 6-24.

Table 6-24 PGA Score and Number of Grids of each Score

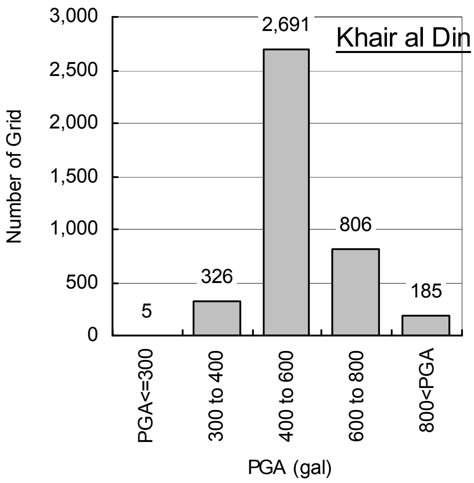
Score	PGA (gal	Khair al Din		Zemmouri	
		Nos. Grid	Ratio (%)	Nos. Grid	Ratio (%)
1	150 or less	0	0.0%	75	1.9%
2	150 < PGA ≤ 200	0	0.0%	983	24.5%
3	200 < PGA ≤ 250	0	0.0%	619	15.4%
4	250 < PGA ≤ 300	5	0.1%	277	6.9%
5	300 < PGA ≤ 350	76	1.9%	200	5.0%
6	350 < PGA ≤ 400	250	6.2%	191	4.8%
7	400 < PGA ≤ 450	1,087	27.1%	212	5.3%
8	450 < PGA ≤ 500	424	10.6%	266	6.6%
9	500 < PGA ≤ 550	783	19.5%	223	5.6%
10	550 < PGA ≤ 600	397	9.9%	308	7.7%
11	600 < PGA ≤ 650	341	8.5%	114	2.8%
12	650 < PGA ≤ 700	216	5.4%	84	2.1%
13	700 < PGA ≤ 750	136	3.4%	76	1.9%
14	750 < PGA ≤ 800	113	2.8%	80	2.0%
15	800 < PGA ≤ 850	71	1.8%	70	1.7%
16	850 < PGA ≤ 900	52	1.3%	53	1.3%
17	900 < PGA ≤ 950	24	0.6%	78	1.9%
18	950 < PGA ≤ 1,000	17	0.4%	55	1.4%
19	more than 1,000	21	0.5%	49	1.2%
Total		4,013	100 %	4,013	100 %

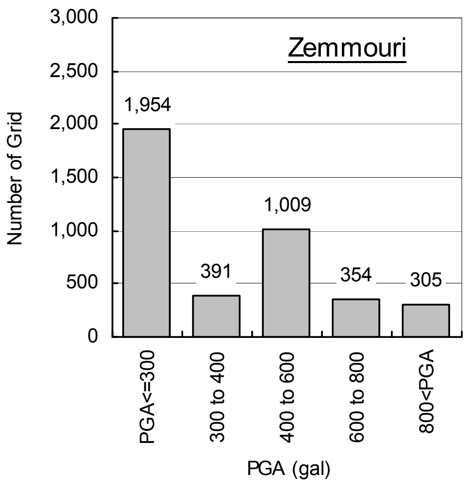


- 2nd: The PGA score is classified into 5 grades based on the data distribution for the Khair al Din case (because it shows roughly even distribution) as shown in Table 6-25. The grade "V" shows the highest risk. This means that there is a high probability for a facility to suffer some form of damage.

Table 6-25 Definition of Grade by PGA and Summary of Number of Grids of each Grade/Score

Grade	Score	PGA (gal	Khair al Din		Zemmouri	
			Nos. Grid	Ratio (%)	Nos. Grid	Ratio (%)
I	1 – 4	300 or less	5	0.1%	1,954	48.7%
II	5 – 6	300 < PGA ≤ 400	326	8.1%	391	9.7%
III	7 – 10	400 < PGA ≤ 600	2,691	67.1%	1,009	25.1%
IV	11 – 14	600 < PGA ≤ 800	806	20.1%	354	8.8%
V	15 - 19	more than 800	185	4.6%	305	7.6%
Total			4,013	100 %	4,013	100 %





- 3rd: The liquefaction potential (PL) and the slope failure risk (SR) threats as a coefficient for the above mentioned grade by PGA. This means that if there are 2 grids of the same PGA, one that has liquefaction potential and the other does not, the former grid may have a greater risk (dependent on the PL value). The PL and the SR is given a score, and then the score (by PL and SR) is added to the PGA score. The total score is compared with the threshold to decide the grade by PGA (refer to Table 6-25). Tabulation of the total score and the risk grade is shown in Table 6-26.

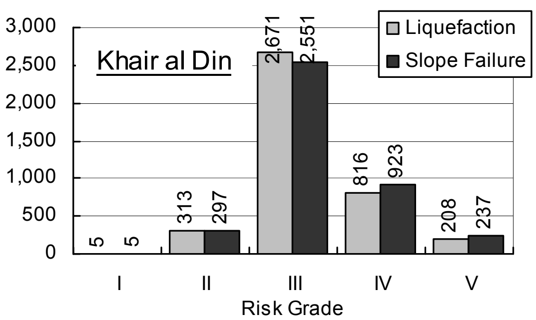
Table 6-26 Definition of Risk Grade by Combination of PGA and Liquefaction Potential / Slope Failure Risk

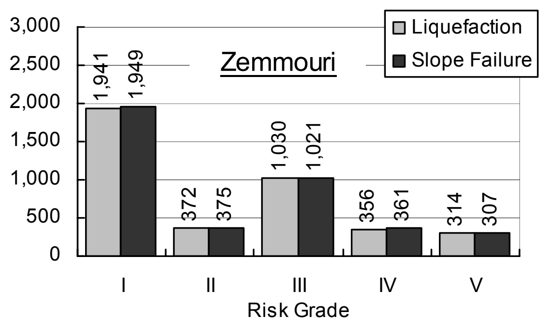
Risk Grade	Score / PGA Score	Liquefaction Potential					Slope Failure Risk			
		No	PL=0	0<PL≤5	5<PL≤15	15<PL	No	0<SR≤5	5<SR≤50	50<SR
		0	1	2	4	6	0	1	2	4
I	1	1	2	3	5	7	1	2	3	5
	2	2	3	4	6	8	2	3	4	6
	3	3	4	5	7	9	3	4	5	7
	4	4	5	6	8	10	4	5	6	8
II	5	5	6	7	9	11	5	6	7	9
	6	6	7	8	10	12	6	7	8	10
III	7	7	8	9	11	13	7	8	9	11
	8	8	9	10	12	14	8	9	10	12
	9	9	10	11	13	15	9	10	11	13
	10	10	11	12	14	16	10	11	12	14
IV	11	11	12	13	15	17	11	12	13	15
	12	12	13	14	16	18	12	13	14	16
	13	13	14	15	17	19	13	14	15	17
	14	14	15	16	18	20	14	15	16	18
V	15	15	16	17	19	21	15	16	17	19
	16	16	17	18	20	22	16	17	18	20
	17	17	18	19	21	23	17	18	19	21
	18	18	19	20	22	24	18	19	20	22
	19	19	20	21	23	25	19	20	21	23

- 4th: The above mentioned grade is calculated for each grid. Table 6-27 and Figure 6-40 / Figure 6-41 shows the number of grids classified by each risk grade and the geo-hazard map by PGA-liquefaction potential / PGA-slope failure risk, respectively.

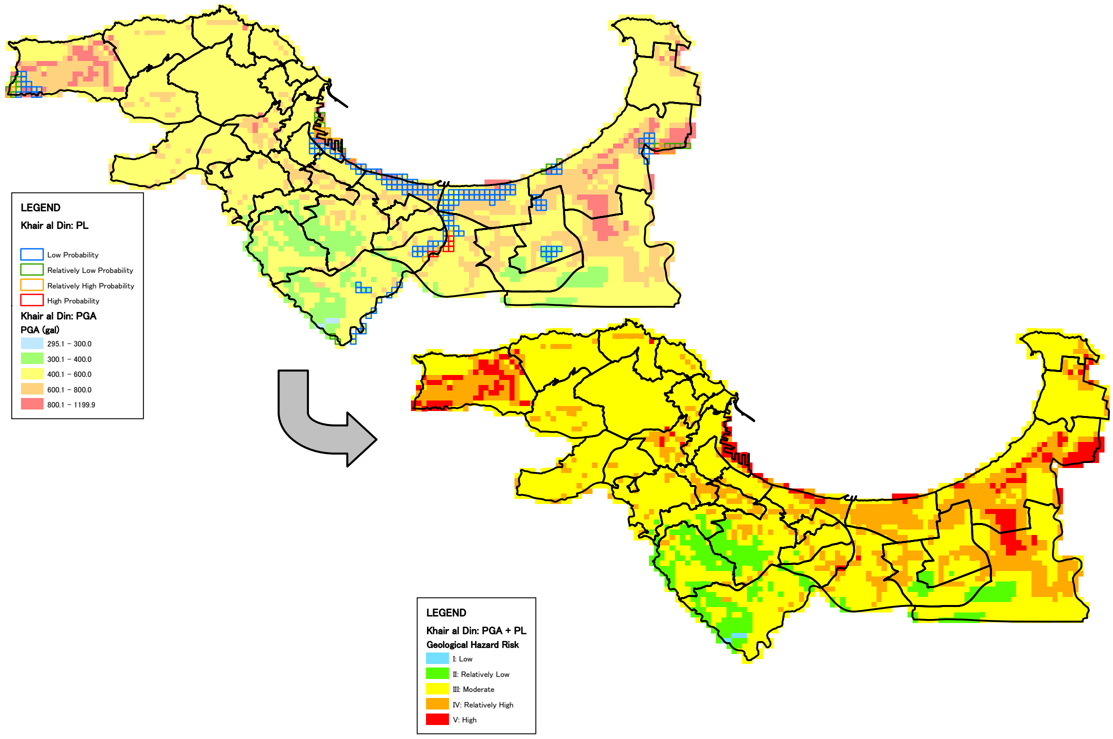
Table 6-27 Summary of Number of Grids classified by Risk Grade

Risk Grade	Total Score	Khair al Din				Zemmouri			
		PGA + Liquefaction		PGA + Slope Risk		PGA + Liquefaction		PGA + Slope Risk	
		Nos. Grid	Ratio (%)	Nos. Grid	Ratio (%)	Nos. Grid	Ratio (%)	Nos. Grid	Ratio (%)
I	1 – 4	5	0.1%	5	0.1%	1,941	48.4%	1,949	48.6%
II	5 – 6	313	7.8%	297	7.4%	372	9.3%	375	9.3%
III	7 – 10	2,671	66.6%	2,551	63.6%	1,030	25.7%	1,021	25.4%
IV	11 – 14	816	20.3%	923	23.0%	356	8.9%	361	9.0%
V	15 - 25	208	5.2%	237	5.9%	314	7.8%	307	7.7%
Total		4,013	100 %	4,013	100 %	4,013	100 %	4,013	100 %





Khair al Din



Zemmouri

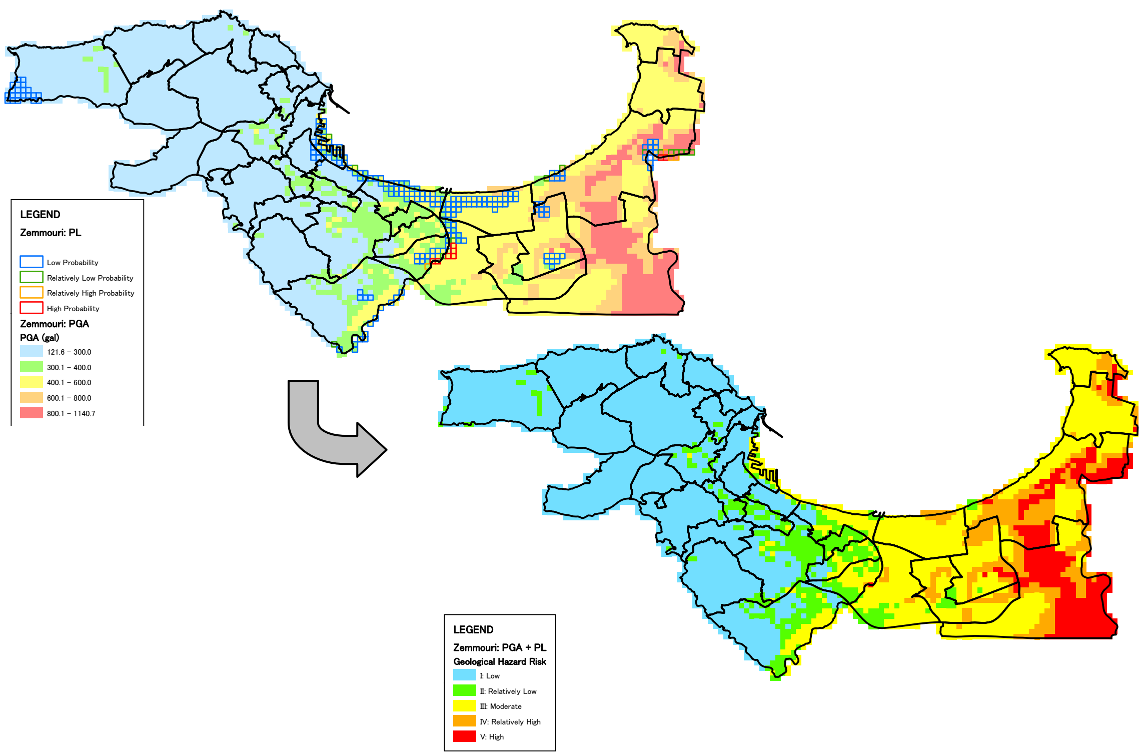
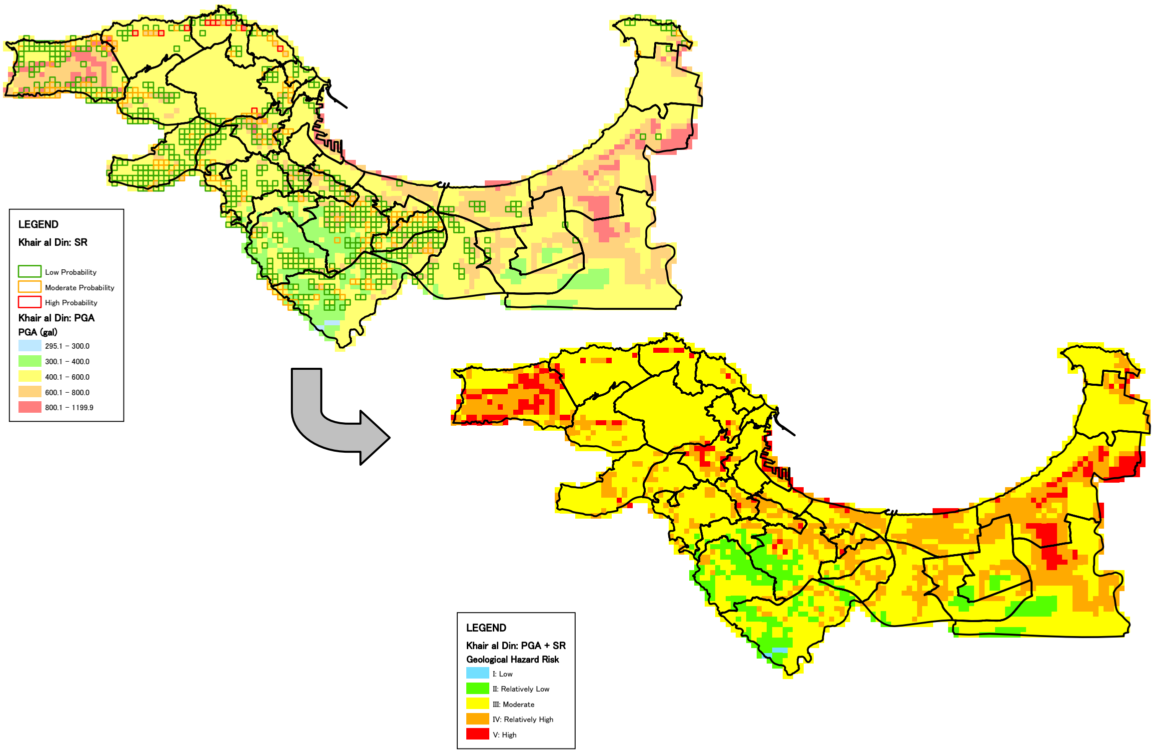


Figure 6-40 Geo-Hazard Map by PGA and Liquefaction Potential

Khair al Din



Zemmouri

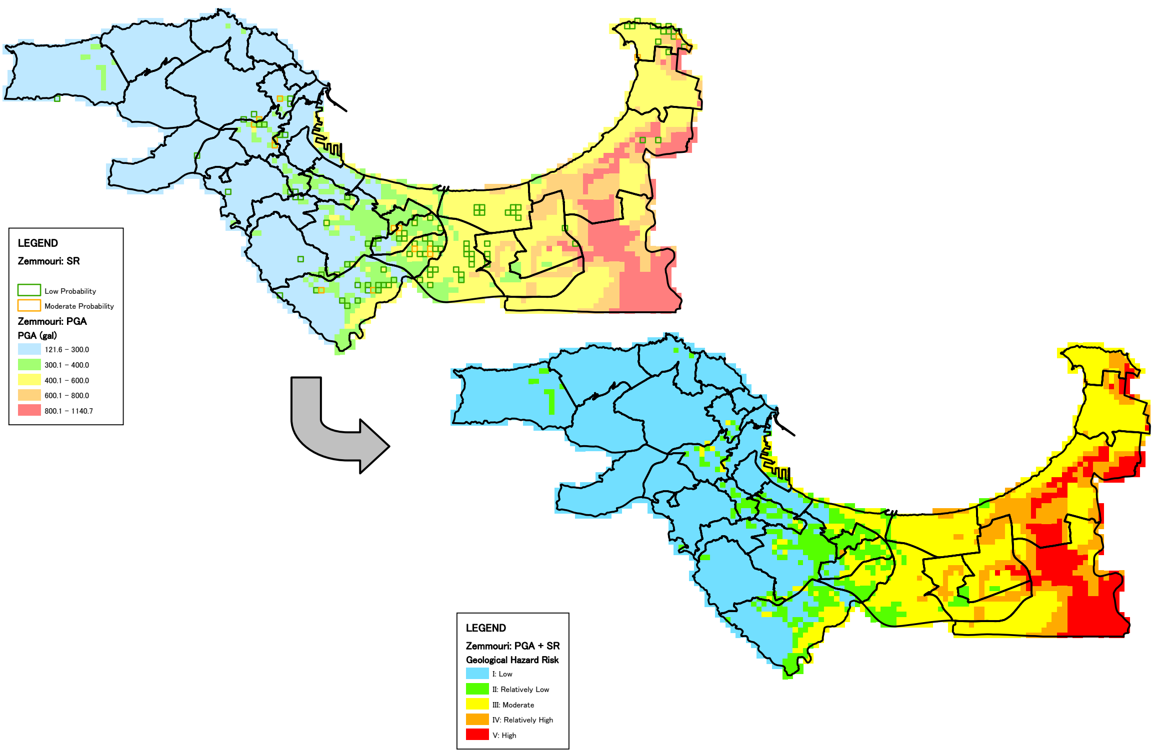
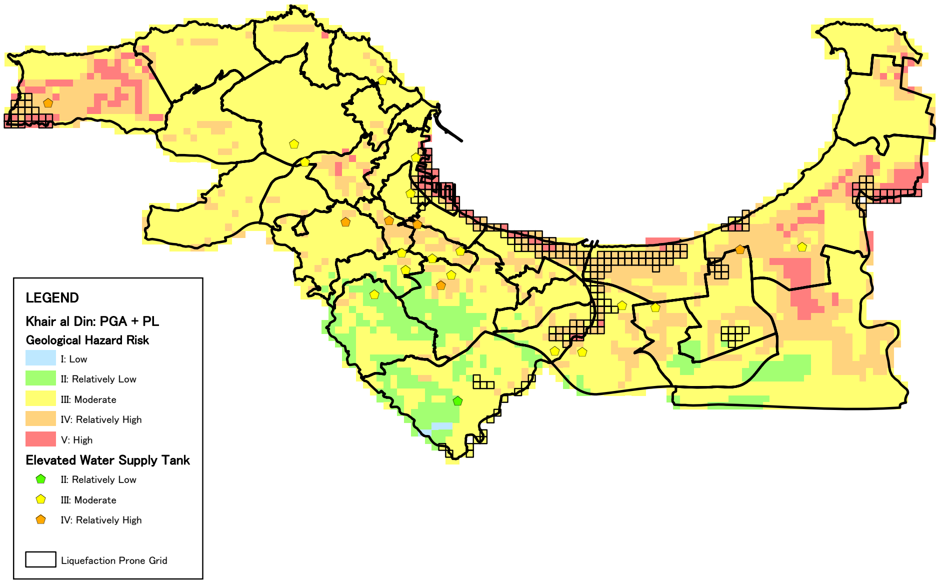


Figure 6-41   Geo-Hazard Map by PGA and Slope Failure Risk

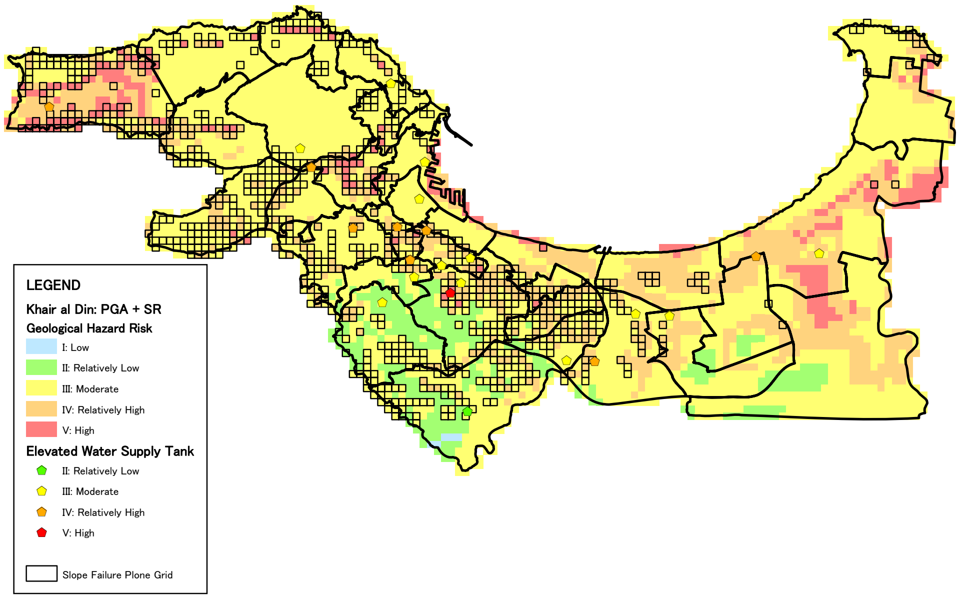
2) Result

Figure 6-42 and Figure 6-43 shows the tank locations on the geo-hazard map for the Khair al Din and the Zemmouri cases, respectively.

In the case of Khair al Din, the tanks are not located in the liquefaction prone grid sectors; however, 6 tanks out of 23 tanks are located in the relatively high risk grid sectors due to the PGA. Meanwhile, 8 tanks are located in the slope failure prone grid sectors, and one of them (Sidi Garidi, in Kouba) is located in a high risk grid sector due to the combined PGA and slope failure risk.



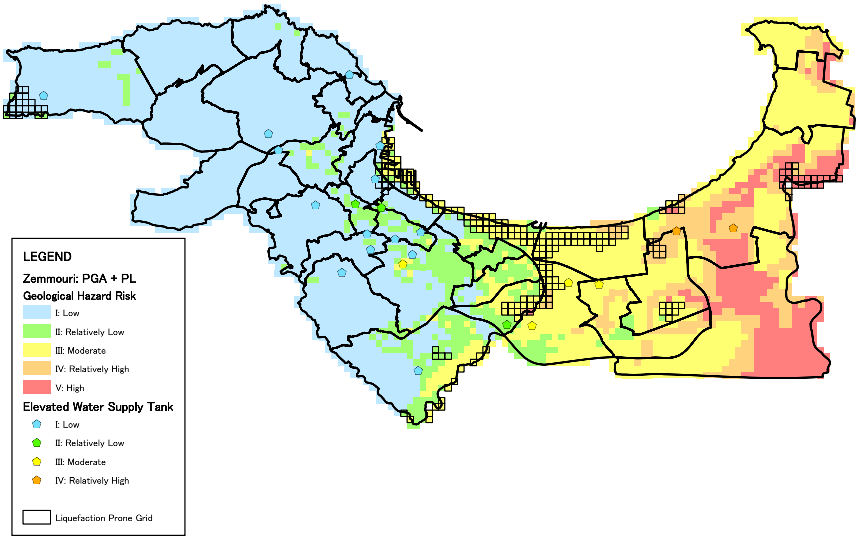
[Geo-hazard map: PGA + Liquefaction Potential]



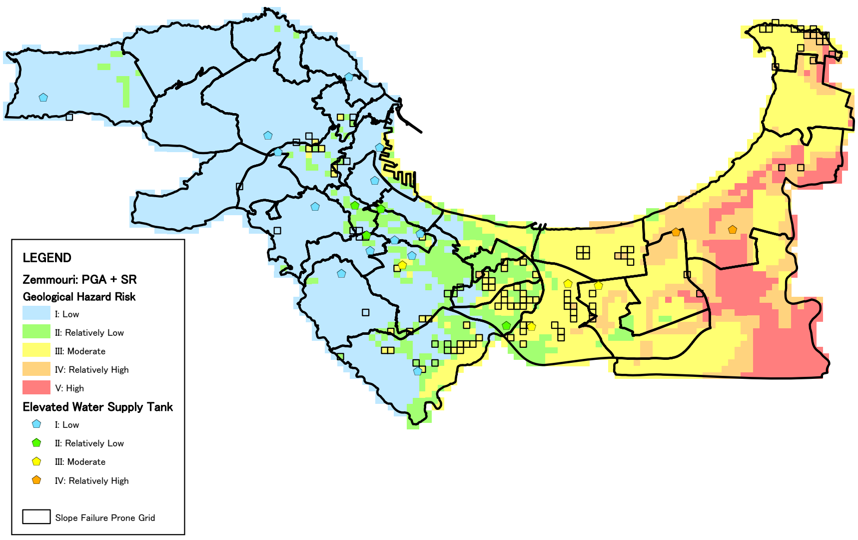
[Geo-hazard map: PGA + Slope Failure Risk]

Figure 6-42 Qualitative Damage Estimation for Elevated Water Supply Tanks: Khair al Din

In the case of the Zemmouri event, the tanks are not located in liquefaction prone grid zones; however, 2 tanks out of 23 tanks are located in relatively high risk grid zones due to the PGA. Further, two tanks are located in the slope failure prone grid zones, and the risk is between relatively low and moderate.



[Geo-hazard map: PGA + Liquefaction Potential]



[Geo-hazard map: PGA + Slope Failure Risk]

Figure 6-43 Qualitative Damage Estimation for Elevated Water Supply Tanks: Zemmouri

3) Discussion

At the tanks located in high acceleration or high slope failure risk zones should be given an individual seismic assessment (ground and structure condition, etc) and the actual slope condition should be determined for its surroundings (positional relation between the tank and slope, slope stability, etc). Then the necessity of retrofitting work for aseismic should be examined.

6-3-5 Sewerage Pipelines

Sewerage pipeline data, including a location map and its attribute data, sheet was provided by DHW, however, some pipeline material and diameters were not known. Meanwhile, the provided pipelines were main networks and the pipeline structures generally have good performance against an earthquake. Hence, vulnerability of the sewerage pipeline for the scenario earthquake was evaluated qualitatively by overlaying the pipeline network on the geo-hazard map (described in section 6-3-4).

(1) Evaluation of Vulnerability

Four categories of sewer lines were overlaid on the geo-hazard map, existing lines of modern construction, existing old lines (colonial age), lines that are currently under construction and planned pipelines.

(2) Results

Figure 6-44 and Figure 6-45 shows the results of the vulnerability evaluation in case of events similar to the Khair al Din and the Zemmouri quakes, respectively.

Table 6-28 and Table 6-29 shows projected the results of events similar to the Khair al Din and the Zemmouri quakes, respectively.

Table 6-28 Areas Evaluated as Relatively High Risk and High Risk for the Sewerage Pipelines:Khair al Din

Sewerage Pipelines	Evaluated Relatively High and High Risk Areas		
	PGA	PGA + Liquefaction Potential	PGA + Slope Failure Risk
Existing Pipelines	A part of Bordj El Kiffan, Bordj El Bahri and El Marsa	Along Elharrach river in Bachdjarah and Bourouba West part of Ain Benian	North and west part of Ain Benian
Old Pipelines	-	Along the coastline in Alger Centre, Hussein Dey, and Mouhammadia	El Biar, El Magharia and Bachd Jarah
Under Construction Pipelines	South part of Bordj El Kiffan	Along the coastline in Alger Center, Hamma El Annasser, Hussein Dey, and Mouhammadia	South part of Bouzareah
Planned Pipelines	-	South-west of Ain Benian	South part of Ain Benian, south-west part of Beni Messous and Bachd Jarah

Table 6-29 Areas Evaluated as Relatively High Risk and High Risk for the Sewerage Pipelines: Zemmouri

Sewerage Pipelines	Evaluated Relatively High and High Risk Area		
	PGA	PGA + Liquefaction Potential	PGA + Slope Failure Risk
Existing Pipelines	A part of Bordj El Kiffan, Bordj El Bahri and El Marsa	Along Elharrach river in El Harrach	-
Old Pipelines	-	Along the coastline in Mouhammadia	-
Under Construction Pipelines	A part of Bordj El Kiffan	Along the coastline in Mouhammadia East part of Bord El Kiffan	-
Planned Pipelines	-	-	-

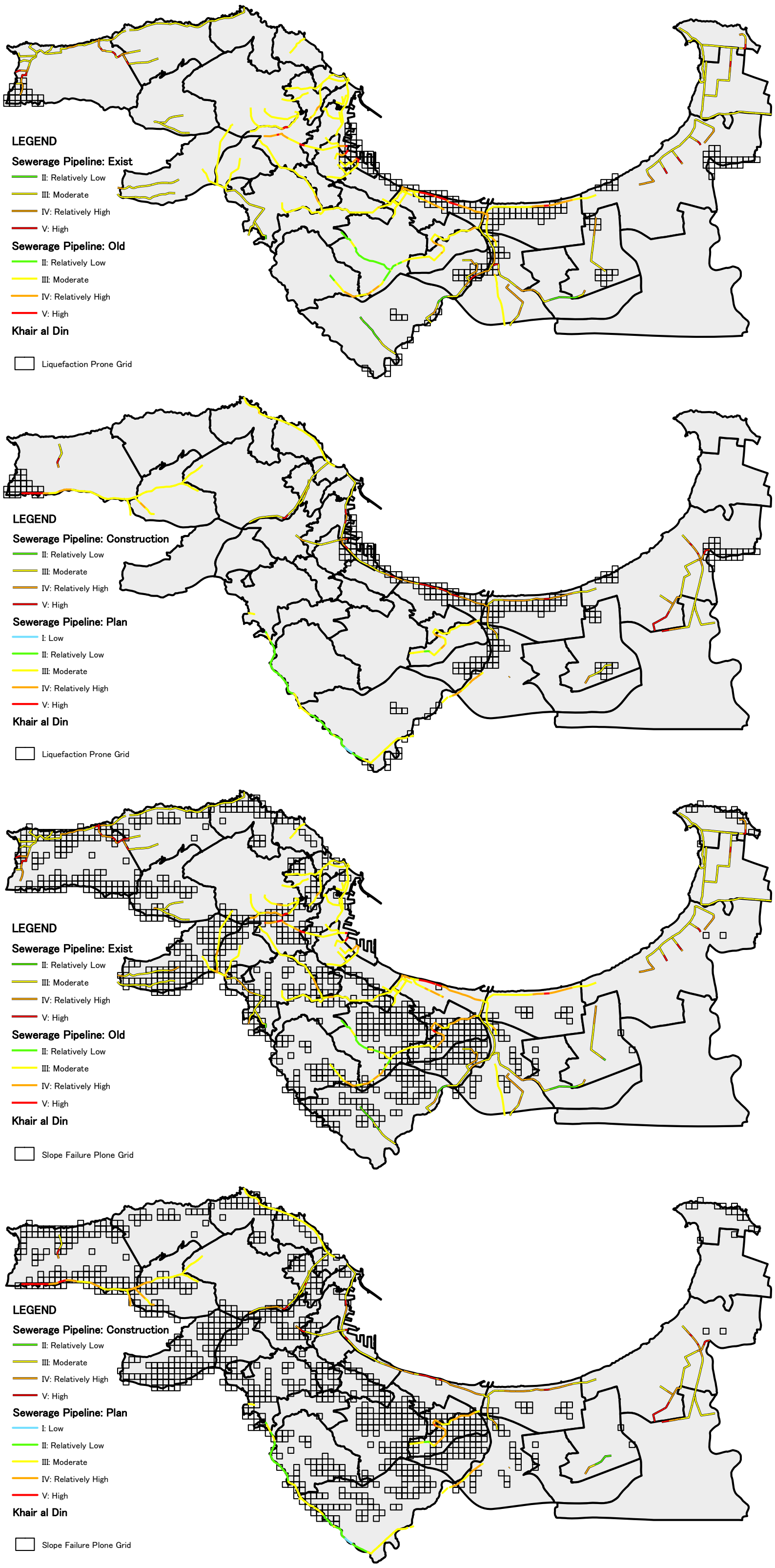


Figure 6-44 Qualitatively Damage Estimation for Sewerage Pipelines: Khair al Din

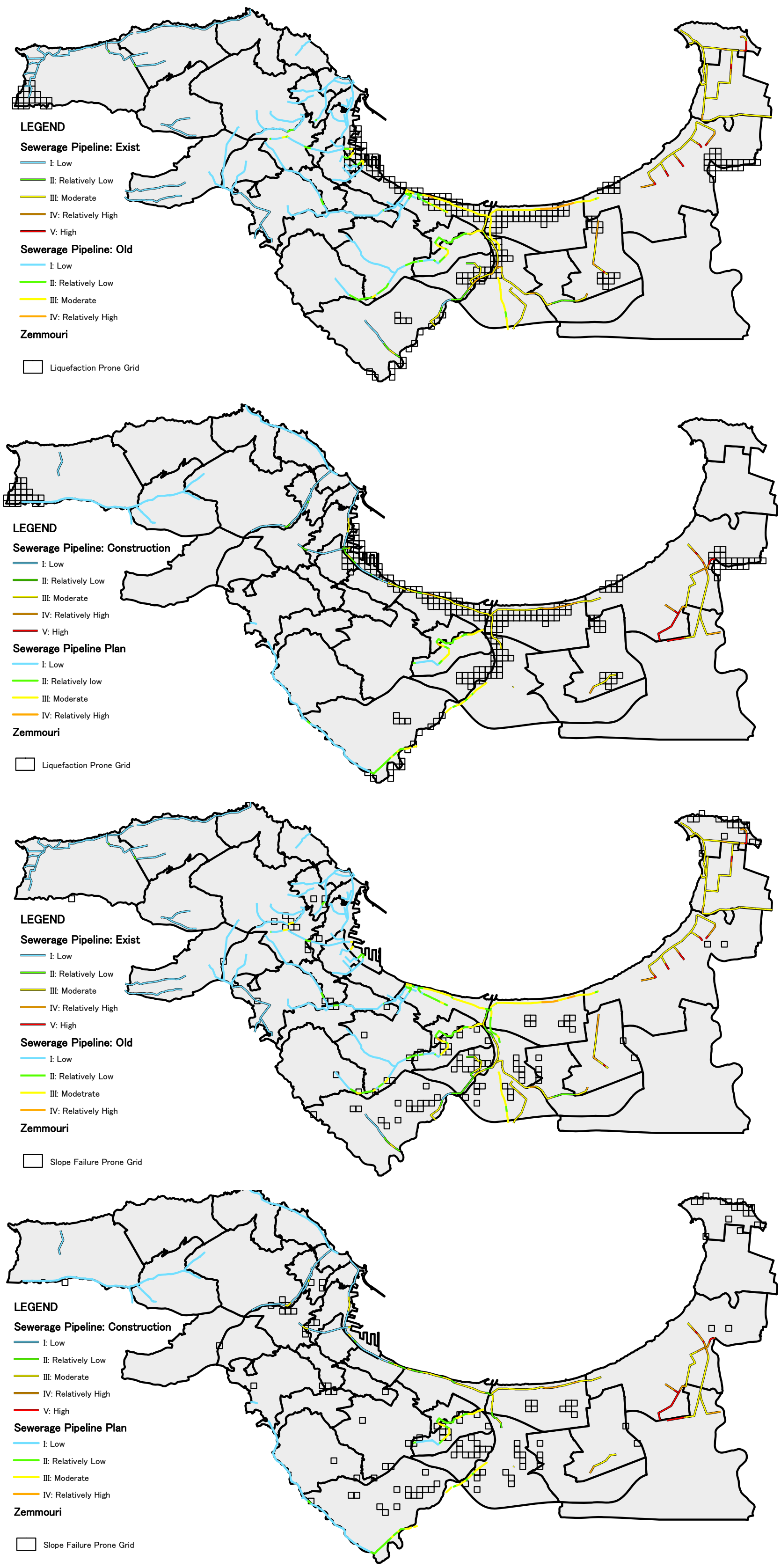


Figure 6-45 Qualitative Damage Estimation for Sewerage Pipelines: Zemmouri