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Asteroids Deep Ocean Impact and the Short-Term Consequences to the Portuguese Territory and Population
(versão corrigida após defesa)

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Resumo

O impacto de asteroides é uma ameaça global estabelecida. Cada local na Terra tem uma probabilidade de impacto de asteroides, à partida semelhante, que é limitada pelo conhecimento atual da humanidade. Como a superfície da Terra é maioritariamente água, um impacto de asteroides na água é duas vezes mais provável do que um impacto no solo. Os impactos no oceano estão naturalmente mais distantes das áreas povoadas, mas podem ainda representar uma ameaça significativa.

Os impactos têm probabilidades baixas, mas consequências elevadas, tornando-os um conceito difícil para o público, uma vez que tais acontecimentos não acontecem no dia a dia. Embora os impactos de asteroides tenham provado ser letais no passado, ainda é necessário aumentar a consciência pública para este perigo. A potencial devastação global obriga a medidas de mitigação que viriam naturalmente com a consciencialização.

Nesta dissertação, foi assumido um impacto de asteroides no oceano e os efeitos imediatos do impacto foram avaliados para os municípios portugueses. A localização do impacto foi fixa num ponto médio entre Portugal Continental, e as ilhas dos Açores e da Madeira. Foi assumido que todos os asteroides impactariam a Terra com um ângulo de 45 graus. O estudo abrange abalos sísmicos, ondas de pressão, depósito de ejeta, radiação térmica e ondas de *tsunami*; bem como as possíveis implicações globais na Terra, a perturbação da órbita, mudança no período de rotação, variação da inclinação do eixo, e perda de massa. Foram também estimadas as vulnerabilidades e fatalidades para cada município e cada efeito de impacto.

Num impacto de asteroides no oceano, longe das regiões costeiras, o depósito de ejeta e o abalo sísmico são os efeitos menos significativos e podem ser ignorados. A radiação térmica tem um curto alcance e pode ser desconsiderada para os asteroides menores. A onda de pressão é experienciada para os três impactos, mas os seus danos são, na sua maioria, estruturais. O *tsunami* é de longe a maior ameaça dum impacto de asteroides no oceano.

Palavras-chave

Asteroides, impactos, efeitos de impacto, municípios, vulnerabilidades e fatalidades.

Abstract

The impact of asteroids is an established global threat. Every location on Earth has a similar, a priori likelihood of an asteroid impact, which is limited by the current humankind's knowledge. As Earth's surface is mostly water, a water asteroid impact is twice as likely as a ground impact. Ocean impacts are naturally more distant from populated areas but can still pose a significant threat.

Impact events have a low probability but high consequences making them a hard concept to the public as such happenings do not occur in the day-to-day life. Even though asteroid impacts have been proven to be lethal in the past, increasing public awareness to this hazard is still needed. The potential global devastation obliges mitigation measures that would come naturally with the awareness.

In this dissertation, an ocean asteroid impact was assumed and the immediate impact effects were assessed for the Portuguese municipalities. The impact location was set in a midpoint between mainland Portugal, Azores and Madeira islands. All asteroids were assumed to impact the Earth at a 45 degrees angle. The study covers seismic shaking, overpressure, ejecta deposit, thermal radiation and tsunami waves; as well as the possible global implications on Earth, in terms of orbit disturbance, change in rotation period, axis tilt variation, and lost mass. The vulnerabilities and casualties for each individual municipality and each impact effect were also estimated.

In an asteroid ocean impact far from coastal regions, the ejecta deposit and seismic shaking are the less significant effects and can be disregarded. The thermal radiation has a small reach and can be disregarded for minor asteroids. The shock wave is experienced for all three impacts, but its damage is mostly structural. The tsunami is by far the biggest threat in an asteroid impact on the ocean.

Keywords

Asteroids, impact, impact effects, municipalities, vulnerabilities and casualties.

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Nomenclature

AU	Astronomical Unit ($1.4960 \times 10^8\ km$)
CA	Close-Approach
LD	Lunar Distance
NASA	National Aeronautics and Space Administration
NEA	Near-Earth Asteroid
NEO	Near-Earth Object
TNT	Trinitrotoluene
a	Semi-major axis
$A(D)$	Rumpf's rim wave amplitude
A_{800}	Wave amplitude at the deep/shallow water threshold
A_{cw}	Collapse wave amplitude
A_{cw}^{max}	Collapse wave maximum amplitude
A_{rw}	Collins's rim wave amplitude
A_{rw}^{max}	Collins's rim wave maximum amplitude
C_D	Drag coefficient
C_e	Ejecta blanket deposition casualties
C_p	Overpressure casualties
C_{seis}	Seismic shaking casualties
C_{tsu}	Tsunami casualties
C_ϕ	Thermal radiation casualties
D	Distance
D_1	Yield scaled distance
D_c	Threshold diameter between simple and complex craters
d_{fc}	Final crater depth
D_{fr}	Final crater diameter
D_{shore}	Distance between the municipality and the deep/shallow water threshold point
d_{tc}	Transient crater depth
D_{tr}	Transient crater diameter
D_x	Scaled distance
E	Impact energy
e	Ellipticity
E_{kt}	Impact energy in kilotons TNT
f	Ratio of the fireball above the horizon
g_0	Earth standard gravitational acceleration ($9.80665\ m/s^2$)
h_{sea}	Sea depth at impact site
H	Absolute magnitude
h	Fireball maximum height below the horizon
h_{fr}	Rim height
h_k	Municipality altitude
L	Asteroid diameter

L_e	Mean ejecta fragment diameter
M	Seismic Ritcher scale magnitude
$m_{\earth}$	Earth mass
m_i	Impactor mass
M_{eff}	Effective seismic Ritcher scale magnitude
M_i	Impactor linear momentum
$R_{\earth}$	Earth radius
R_f	Fireball radius
p_D	Peak overpressure at distance D
p_e	Load of the ejecta blanket
p_x	Scaled pressure
q	Wave attenuation factor
s	Municipality slope
$T_{\earth}$	Earth rotation period
t_{br}	Breccia lens thickness
t_e	Ejecta blanket thickness
T_e	Ejecta arrival time
T_s	Seismic waves arrival time
T_w	Tsunami waves arrival time
U	Run-up wave height
U_l	Local run-up wave height
V	Volume
$V_{\earth}$	Earth volume
$v_{\earth}$	Earth mean orbital velocity
V_{br}	Unbulked breccia lens volume
V_e	Ejecta blanket deposition vulnerability
v_e	Ejecta velocity
v_i	Impact velocity
V_p	Overpressure vulnerability
V_{seis}	Seismic shaking vulnerability
V_{tc}	Transient crater volume
V_{tsu}	Tsunami vulnerability
V_{ϕ}	Thermal radiation vulnerability
$\Gamma_{\earth}$	Earth angular momentum
Γ_i	Impactor angular momentum
Δ	Epicentral angle
$\Delta T_{\earth}$	Change in Earth's length of day
η_{lum}	Luminous efficiency
θ	Asteroid impact angle
λ_i	Impact site longitude
λ_k	Municipality longitude
ρ_i	Impactor density

ρ_t	Target density
ρ_w	Water density
ϕ	Thermal energy per area unit
ϕ_i	Impact site latitude
ϕ_k	Municipality latitude

Chapter 1

Introduction

Telling the story of Earth impacts is telling the story of Earth itself. Asteroids have been colliding with the Earth since its genesis. Asteroid impacts have been responsible for a couple of mass extinctions that hindered the development of life. The most well-known event of this scale is the one theorized to be the cause for the dinosaurs' extinction 66 million years ago [1]. The low probability nature of such events, along with its massive potential destructive capabilities make it a hard concept to grasp by common people whose concerns lie on the everyday life. However, the asteroid threat is real and, most recently, in 2013 the Chelyabinsk airburst event of an $\sim$20-meter object has made this potential threat more tangible to the public and the scientific community [2].

Near-Earth objects, or NEOs, are any small Solar System object with an orbit close to Earth's. Asteroids and comets can fall into this classification. Near-Earth asteroids (NEA) are thus celestial objects with a near-Earth orbit but without the comet's characteristic tail. There are two major independent classifications to which an NEA can belong, the first based on its orbit and the second based on its spectral type. The orbital classification is based on the semi-major axis, perihelion, and aphelion of the specific asteroid whereas the asteroid spectral type is based on its emission spectrum, colour, and albedo.

An NEA can belong to either Atira, Aten, Apollo or Amor groups based on its orbit [3][4]. Atiras and Amors have orbits that do not cross Earth's orbit and thus are not immediate impact threats. Their orbit can, however, suffer external gravitational influences and become Earth-crossing orbits. The distinction between these two groups is that Atira asteroids orbit are completely confined within Earth's orbit, *i.e.,* their aphelion is smaller than Earth's perihelion, whilst the Amor asteroids have an orbital perihelion greater than the Earth's aphelion, *i.e.,* their orbit is confined between Earth's and Mars' orbits. Apollo and Aten asteroids have Earth-crossing orbits and are therefore the most potentially hazardous. Apollos have a semi-major axis larger than Earth's whereas Atens have a semi-major axis smaller than Earth's.

A taxonomy system that classifies asteroids based on its spectral type was first developed by Chapman *et al.* in [5]. Three different categories were introduced, 'C' for dark carbonaceous objects, 'S' for siliceous objects and 'U' for any other object that did not fit into the previous categories. Since it was first introduced, this classification has been expanded and complemented by numerous authors. Bus and Binzel in [6] proposed a taxonomy reformulation utilizing new data with a far higher resolution than the data used in the previous established taxonomy system. In this new classification, the albedos were not included, however, an attempt was made to keep correspondence between the previous and the new taxonomy. In this taxonomy, the asteroids were sorted into 26 classes, some of which can be intermediate classifications between two different type's spectra.

The NASA NEO list [7] was used to verify which celestial objects are on a near-Earth orbit and their estimated diameter and velocity. Between 10 March 2020 and 29 November 2200, have pass and will pass 9000 plus objects with close approach nominal distances of less than 0.05 au. This list is constantly being updated by new observations, which means that the real number of potential threats could be higher. Aided by the code presented in Appendix C.3, the average diameter and velocity of these objects was found to be $204\ m$ and $10.84\ m/s$, respectively. This medium asteroid tries to represent the average threat all this objects pose as of the current knowledge.

1.1 Apophis

The Apophis is an asteroid discovered in 2004 with an estimated diameter of 370 m [8][9]. It is one of the most well-known asteroids in the scientific community and the public due to the initial observations that indicated a high probability of impact in 2029. This initial threat granted the asteroid a value of 4 on the Torino scale, the highest value an asteroid has ever reached. The impact was refuted with updated observations, however, the possibility remained that the asteroid would pass through a gravitational keyhole[1] that would set the asteroid on an Earth collision orbit with a future impact in 2036 [10]. Newer observations ruled out this possibility [11], resetting the Torino scale value to zero.

Apophis is an Aten asteroid based on its orbit and an Sq-type asteroid that resembles a LL ordinary chondrite meteorite in terms of spectral characteristics. This close comparison allowed to estimate the bulk density of the asteroid to $3.2\ g/cm^3$ [12].

1.2 Impact Hazard Scales

1.2.1 Torino

The Torino Impact Hazard Scale [13] was developed to categorize and communicate to the public the impact hazard of any given impact event. The fact that low probability/high consequence events are not within the common grasp of human experience creates a communication risk challenge that the developed scale intends to address.

The scale combines the event probability with its assumed kinetic energy on a 10-point integer scale, which paired with a close encounter date comprises the entire extent of the scale. A 0 corresponds to an event with no hazard associated, its probability is zero or close to zero.

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[1] A gravitational keyhole is a region of space where a planet's gravity would alter a passing asteroid's orbit that would set up a future collision with that planet.

An event named normal, Level 1 on the scale, is one that does not pose an unusual level of danger and new observations will most likely reassign it to Level 0. Levels 2 through 4 correspond to events that merit astronomers' attention but will, most likely, be reassigned to Level 0. Level 2 corresponds to close but not highly unusual events while Levels 3 and 4 correspond to events with a 1% or higher chance of collision capable of localized and regional destruction, respectively. Threatening events are allocated in the Levels 5, 6 and 7. These are events with increasing hazard and/or probability. The impact is still uncertain and critical monitoring is demanded from astronomers. Levels 8 through 10 correspond to certain collisions with increasing devastation capabilities. Level 8 is an event capable of localized destruction and occur on average between once per 50 years or once per 1000 years while Level 9 events are capable of regional devastation and occur between once per 1000 years and once per 100 000 years. Level 10 events may endanger civilization itself as we know it, such events occur on average once per 100 000 years. Complementary to the integer value and the foregoing descriptive wording is also a colour coding to allow a better understanding of any scale value.

The Torino Scale is a unidimensional representation of a multidimensional problem. Therefore, when reporting to the public an event that may represent a serious potential threat, more context information, other than the close encounter date and the integer itself, is needed for there to be clear and responsible communication.

1.2.2 Palermo

The Palermo Technical Impact Hazard Scale [14] arose from the explicit limitations of the Torino Scale. The time interval until the predicted event is not included in the scale itself, leading to similar scenarios with vast impact date differences receiving the same value. An integer scale usage creates ambiguity amidst two distinct events catalogued with the same value. Lastly, it assigns the value 0 to any event that does not merit public interest even if the event could have scientific importance. The Torino Scale is very effective at communication impact risk to a wide and diverse audience whilst lacking when used for communications among impact hazard experts.

The Palermo Scale is a logarithmic scale that combines the impact date, impact energy and impact probability into a single value, it compares the discovered potential impact with the background risk, which can be defined as the average risk posed by objects of the same or larger size until the date of impact in question. A rating below -2 reflects events that are likely to have no consequences, since the event is 100 less likely than the background risk. Values between -2 and 0 correspond to events that merit careful monitoring. A value of 0 denotes a hazard equivalent to the background risk. Positive values usually correspond to events that merit some level of concern, a value of +2 indicates an event that is 100 more likely than the background risk.

1.3 Literature Review

There are several authors that research asteroids impact, with quite relevant investigations in this field. Binzel in [13] devised a 10-point scale that allows a clear and consistent public communication on asteroids impact hazards. When accompanied by a close encounter date, it provides an immediate sense of context for the potential hazard of the encounter. The Torino scale has inherent limitations, it is a unidimensional solution to a multidimensional problem.

Collins *et al.* in [15] developed algorithms to quantify the principal impact processes that might affect people, infrastructures, and landscapes in the vicinity of an impact event. These novel algorithms include estimations of the asteroid's atmospheric passage outcome, the thermal radiation emitted and the seismic shock intensity. It also includes approximations for the impact crater dimensions and ejecta deposits, as well as the severity of air blast from either airbursts or ground impacts. By simulating hypothetical impact scenarios, the authors discovered that seismic shaking has a wider reach when compared with the reach of both ejecta deposition and air-blast pressure. Thermal radiation is the most devastating event near the impact location. However, due to the Earth curvature, its influence decays over great distances because these locations are shielded from direct radiation. Collins and Melosh in [16] publish an erratum for the fore-mentioned paper. In this publication, the author corrects two typographic errors in two different equations. The author also improves on the publication by exhibiting a way to compute the change in day length caused by an impact, a better scaling law to obtain the final crater's depth and a new simplistic analytical approach to the tsunami hazard.

An oceanic impact differs from a land impact in several aspects, including probability. Oceans cover approximately 70% of Earth's surface, making not only ocean impact more likely but also inferring that most past asteroid impacts on Earth must have occurred in marine environments. For these set of reasons and to possibly being able to quantify the hazard posed by future ocean impacts Wünnemann *et al.* in [17] set out to study the impact of a celestial body in the ocean and the generation of large tsunami waves. By analysing numerical models and experimental results the author reached several interesting conclusions. The author claims that a water depth of 6-8 times the diameter of a stony asteroid is sufficient to completely suppressed cratering formation in the bottom of the ocean. Water impacts generate two different type of water waves: rim waves and collapse waves, both with little in common with traditional earthquake-induced tsunami waves. The author states that rim waves occur only in shallow water and collapse waves occur primarily in deep waters. Finally, the author highlights the large discrepancies in the wave attenuation between numerical models, experimental results and theoretical considerations, and states that our understanding of oceanic impacts remains incomplete and with it remains the possible hazard of impact-generated tsunamis.

The results obtained by Reinhardt *et al.* in [18] show that the celestial objects that pose the greatest risk to populations and infrastructures are between 300 and 1000 meters in diameter. The impact of these objects is more frequent than larger ones and can still produce impact events on a global scale. Three different types of missions capable of altering the orbit of hazardous asteroids to mitigate the risk were compared by the authors. It was concluded that even though each method had a different level of effectiveness, each one of the mitigation measures can be adopted and be successful depending on the situation. Now, the technology able to fend off such threats is likely available if we are given enough time to prepare, which gives great significance to the constant observations and discoveries of new potential threatening asteroids.

Rumpf in [19] found the virtual impacts of the 315 asteroids on NASA's NEO risk list, which includes an assessment of the impact location probability distribution. Only 10 of those asteroids were in a close encounter orbit, the total risk amounted to 29 919 causalities. The author intertwined the potential impact locations with Earth population data to assess the global impact risk, while disregarding the impact effects in this assessment. The risk corridors of this limited 10 asteroids sample were distributed over the entire globe, establishing the asteroid threat as a global issue.

Rumpf *et al.* in [20] reassessed the impacts corridors for 261 observed asteroids that could impact the Earth before 2100. The asteroids' impact probability distribution was intertwined with the world population density resulting in a risk map that shows which nations ought to be more concerned about the asteroid threat, Figure 1.1. This method did not include the impact effects and it was only possible to obtain the relative risk of every nation. Given the definition of risk, a uniform impact probability distribution would result in a risk map resembling a typical global population distribution map. By comparing the risk with the population of the 40 most populous countries, it was observed that the population is a good approximation of the risk, even thou there were some deviations in the distribution. Later in the year, the author in [21] included the ground effects in the analysis and compared both cases. There was a slight change in the results, but not enough to alter the conclusions already made. In the following year, the authors in [22] went into more detail about the impact effect modelling and the asteroid impact risk and relative risk calculation. The two foregoing publications further establish the veracity of the conclusions made in [20]. Population size can suffice as a proxy to identify the countries that would suffer most casualties. However, when faced with a concrete threat, this is insufficient and further analysis must be done to properly assess the risk.

Rumpf in [23] wrote a PhD thesis in which he developed a tool to assess the impact risks of hazardous asteroids. This method expresses the risk in terms of expected casualties and allows the comparison with other natural disasters. To estimate the risk, the author derived and presented vulnerability models that correlate the severity of impact effects with the human population. To determine which impact effects are most hazardous to the human population, multiple global simulations were performed. The impact distribution of NEOs was found to be near uniform and, as such, the global risk distribution closely resembles the

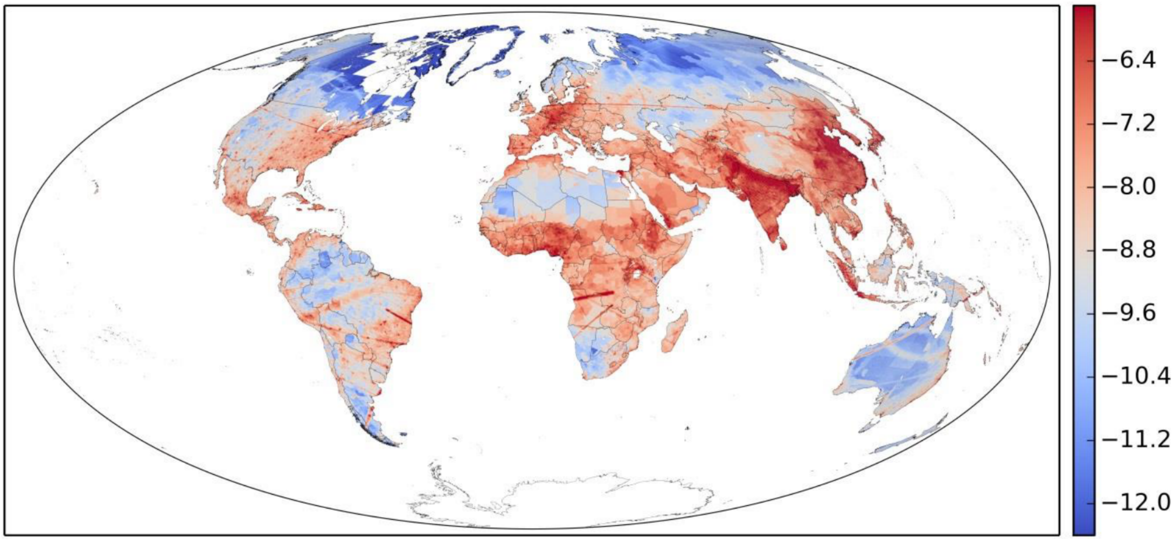

Figure 1.1: Asteroid risk map. Risk is standardized by the global risk and is represented by a colour coding on a logarithmic scale [20].

population distribution, assuming an equal impact probability and population vulnerability. These results allow for better and most efficient preparation of future asteroid threats.

Rumpf *et al.* in [24] calculated once more 261 virtual impacts, this time to assess its longitudinal and latitudinal impact probability distribution. The asteroids' impact probability was set to one and each impact corridor was given the same width, Figure 1.2. Through this approach it becomes unambiguous that impact corridors are evenly distributed. The probability distributions engulf the entire Earth therefore asteroid impacts can occur anywhere. A greater number of samples would tend to uniform the distributions, which is not feasible due to the constant updates the list of the potential threats receives.

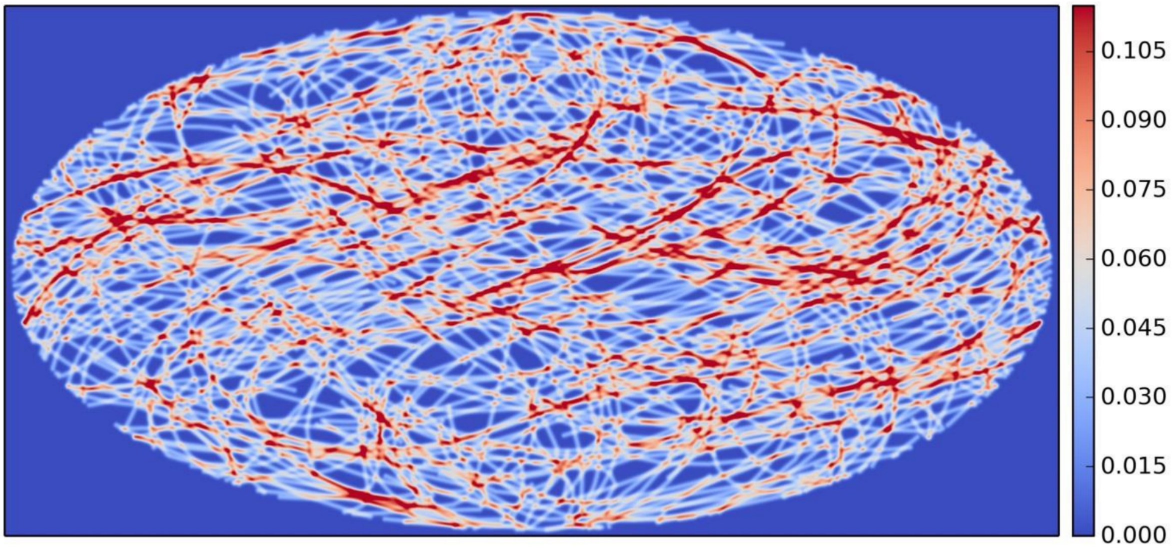

Figure 1.2: Uniform impact corridor distribution. The impact probability and the corridor width of each VI were set to one and 0.01 Earth radii, respectively [24].

Rumpf *et al.* in [25] estimated the total casualties and damage contributions in two case studies as predicted by the impact effects models in [22] and the vulnerability models, presented in this paper, considering the local population and geography. The first case study consists of an airburst and a cratering event with an impactor with 50 and 200 m in diameter, respectively, both over Berlin and London. Concerning the surface impact event, the aerothermal effects, which include wind, pressure, and thermal radiation, accounted for most of the losses while the ground impact effects, seismic shaking, cratering and ejecta, accounted only for about 3% of the losses. In the airburst event, the relative contributions of the aerodynamic and thermal effects were compliant with observations made in the similar impactor sized Tunguska event in 1908. In the second case study, a catering event was generated onshore and the impact location was moved increasingly offshore to assess the varying impact events. The land and near-coast impacts presented the same damage distributions as in the first case. However, as the impact location recedes farther offshore the wind, pressure and thermal vulnerabilities decrease at respectively increasing rates, whereas the tsunami loss contribution is surprisingly low in near-coast areas. The results show, not only each impact effect contribution to the total number of casualties but also how the selection of the best and worst-case vulnerability models affect the total casualties.

The authors in [26] randomly generated an artificial impactor sample, assuming a density of $3.1\ g/cm^3$, covering the globe to assess the increasing number of casualties per impactor size, up to 400 meters, and the continuous contribution of each impact effect. They also obtained the effect loss ratio of each impact effect for land and water. At last, they obtained the average loss in global, land, and water impact scenarios per impactor size; and the percentage of impactors that contributed to loss generation in land, water, or global scenarios per impactor size as well. The asteroids that impact the surface have a minimum 56 m diameter. Asteroids below this size threshold suffer airburst. Overpressure shocks only became lethal for asteroids bigger than 40 m, whilst the minimum asteroid size to cause casualties due to wind blast and thermal radiation is 18 m. In land impacts, wind blast and overpressure are the most critical effect accounting for more than 60% of the losses. Thermal radiation corresponds to less than 30% of the losses, noteworthy is the increase in dominance over other impact effects for larger impactors. The cumulative loss for ground impact effects, such as cratering, seismic shaking, and ejecta deposition corresponds to about 1.28%. Tsunamis are the dominant effect in water impacts, accounting for 70-80% of losses, while only accounting for 20% of the global losses, *i.e.,* land and water impact losses. These results help better understand the asteroid impact hazard, including which impact effects are most and least relevant.

Mathias *et al.* in [27] used cumulative probabilities to allow for a clearer assessment of the meaningful thresholds. Instead of using an average value, it was shown a complete range of potential consequences, and their relative likelihoods, given the uncertain variations of asteroid properties and entry parameters. This new probabilistic asteroid impact risk model was developed to assess the risk that potential asteroid impacts pose to Earth's population. Considering a risk tolerance level of 10^{-6} per year of affecting at least 10 000 people, the smallest asteroid size to constitute a threat was 65 m. Although, given the implications of albedo uncertainty in inferring an asteroid size, the smallest asteroid size dropped to 20 m when assuming an albedo of 0.14. These results can be used to bound potential hazard levels for a wide variety of impact scenarios, assess overall ensemble risk from a general asteroid population, and provide insight into what properties or assumptions most affect the potential consequences.

Table 1.1: NEO Earth Close Approaches. Top 25 objects with the closest nominal distance [7]

Object	**Close-Approach (CA) Date**	**CA Nominal Distance (LD)**	**CA Nominal Distance (au)**	**V relative (km/s)**	**H**	**Estimated Diameter**
(2010 RF12)	2095-Sep-06	0.08	0.00020	7.25	28.4	5.6 m - 12 m
99942 Apophis (2004 MN4)	2029-Apr-13	0.10	0.00025	7.43	19.7	310 m - 680 m
(2007 UD6)	2048-Oct-18	0.15	0.00039	7.03	28.3	5.8 m - 13 m
(2014 HB177)	2034-May-06	0.23	0.00059	6.80	28.1	6.4 m - 14 m
(2007 UW1)	2129-Oct-19	0.24	0.00062	5.56	22.7	77 m - 170 m
(2016 RD34)	2047-Sep-05	0.27	0.00069	3.01	27.6	8.0 m - 18 m
(2016 SU2)	2139-Sep-27	0.27	0.00070	13.03	27.6	8.0 m - 18 m
(2012 UE34)	2041-Apr-08	0.29	0.00073	6.12	23.3	58 m - 130 m
(2011 ES4)	2020-Sep-01	0.32	0.00081	8.16	25.4	22 m - 49 m
(2008 DB)	2032-Aug-14	0.32	0.00083	7.40	25.8	18 m - 41 m
(2017 FU102)	2036-Apr-02	0.34	0.00086	7.65	28.7	4.8 m - 11 m
(2018 GE2)	2042-Oct-30	0.34	0.00088	6.61	27.0	11 m - 24 m
(2012 HG2)	2047-Feb-12	0.37	0.00096	4.11	27.0	11 m - 24 m
(2018 PY7)	2155-Aug-05	0.39	0.00099	10.17	26.8	12 m - 26 m
(2006 GU2)	2050-Oct-09	0.46	0.00118	7.62	27.8	7.3 m - 16 m
(2019 EH1)	2032-Mar-01	0.55	0.00141	14.65	30.1	2.5 m - 5.7 m
(2015 XA378)	2053-Jun-01	0.56	0.00143	18.02	25.9	18 m - 39 m
308635 (2005 YU55)	2075-Nov-08	0.58	0.00150	13.77	21.9	110 m - 250 m
(2018 NL)	2055-Jun-29	0.60	0.00155	8.51	25.4	22 m - 49 m
456938 (2007 YV56)	2101-Jan-02	0.62	0.00160	19.28	21.0	170 m - 380 m
153201 (2000 WO107)	2140-Dec-01	0.63	0.00163	26.02	19.3	370 m - 820 m
(2019 BE5)	2079-Jan-29	0.64	0.00164	13.77	25.1	25 m - 57 m
(2020 GE)	2068-Sep-16	0.64	0.00165	2.72	28.1	6.3 m - 14 m
153814 (2001 WN5)	2028-Jun-26	0.65	0.00166	10.24	18.3	580 m - 1.3 km
(2019 NB7)	2174-Jul-16	0.66	0.00168	12.91	27.4	8.8 m - 20 m

1.4 Objectives

The objective of this work is simulating three independent oceanic impacts in a hypothetical point between mainland Portugal, Azores and Madeira islands and assess the short-term effects for the Portuguese territory. The method used in this work is analytical in nature with numeric simulations. The effects include crater formation, ejected material from the site, thermal radiation, seismic, shock and tsunami waves. Assessing the global implications of the planet's orbit, rotation period, tilt of axis, and mass loss is equally essential. In this work is also assessed the independent vulnerabilities and casualties for each municipality and for each analysed asteroid. The prominent impact effects in each asteroid impact as well as the impact effects which does not pose theoretical threat, *i.e.*, effects that this study claims can be disregarded, given the results' theoretical nature, are also assessed.

The study assumes that the population is not previously warned about the threat. The land orography and weather conditions are not considered. Sophisticated numerical models capable of simulating the propagation of shock waves, tsunami waves, the excavation of the transient crater, and its subsequent collapse, for example, are more precise in determining the proper physical consequences of said effects.

1.5 Dissertation Overview

The current work is organized in five chapters: Introduction, Impact Effects Models, Vulnerability Models, Results and Discussion, and Conclusion and Future Work.

Chapter 2 details the analytical models used to simulate the impact effects of an asteroid collision. The impact location was established and the distance between the impact site and every Portuguese municipality was assessed to obtain the local impact effects. Some impact properties, such as the impact energy, are also described. The impact effects studied include the crater formation and dimensions, a seismic shaking event, a shock wave, thermal radiation, ejected material from the crater and tsunami waves.

Chapter 3 employs the local impact effects to assess each municipality vulnerability. Each vulnerability model, in turn, is partitioned in three case scenarios: best, worst, and expected. A correspondent casualties' value is assessed via the product of the local vulnerability and population.

Chapter 4 exposes and discusses the results obtained for the three asteroid impacts simulated: the Apophis asteroid; a medium asteroid, dimensions obtained as the NEOs average; and a five kilometre-wide asteroid.

The final chapter, Chapter 5, sums the results and conclusions of the entire study. The chapter also presents potential new work that can follow up or substantiate the study.

Chapter 2

Impact Effects Models

In this chapter are presented the analytical mathematical models used to assess the effects of the individual impacts of a general impact event and its effect on the surrounding population. The computation of the impact location and the distances to the location of interest, as well as paramount asteroid impact properties, are described. The impact consequences rely heavily on the impact angle, for this study all impacts were assumed to happen at a $45°$ angle.

2.1 Impact Location

The impact location was decided to be amidst mainland Portugal, Madeira, and Azores. To find this middle point on the surface, first the three set of geodetic coordinates were converted into geocentric coordinates. With the geocentric coordinates, the euclidean middle point was found. This point was then projected onto the Earth's surface and converted back into geodetic coordinates. The impact point coordinates were thus obtained and displayed in Table 2.1. The code representing this calculation process can be found in Appendix C.2. According to Rumpf in [23], the threshold between shallow and deep waters lies in the $800\ m$ depth. Therefore, this set of coordinates correspond to a deep ocean point with a matching depth of $4910\ m$, as can be seen in Figure 2.1.

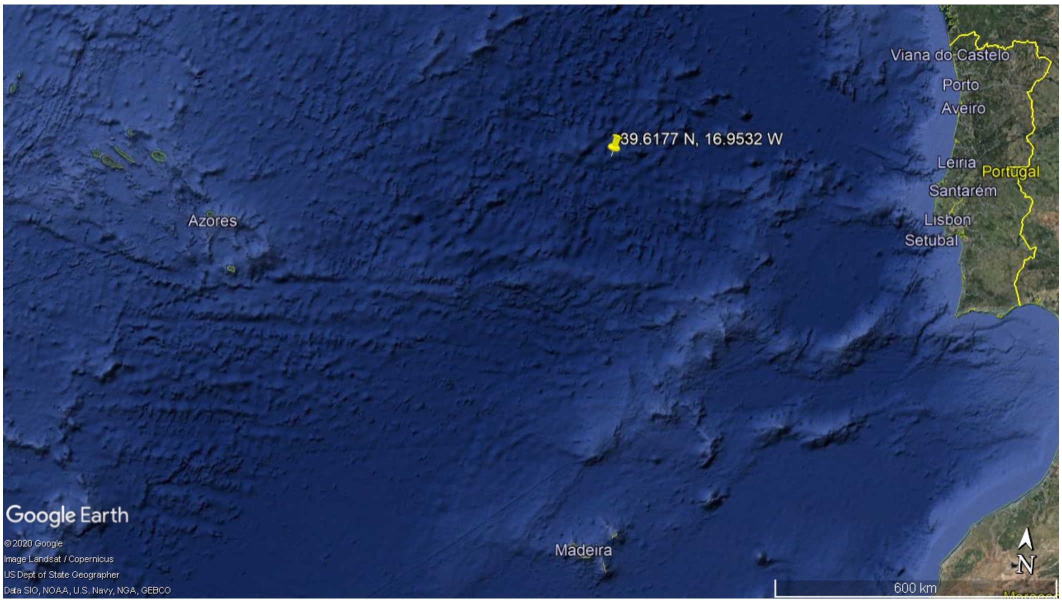

Figure 2.1: Visual representation of the impact site and the Portuguese territory. Obtained through Google Earth.

Table 2.1: Portuguese territory and impact location coordinates

Portugal	39.3999° N, 08.2245° W
Azores	37.7412° N, 25.6756° W
Madeira	32.7607° N, 16.9595° W
Impact Location	39.6177° N, 16.9532° W

2.2 Distances

The Portuguese territory was divided into municipalities to assess each impact effect individually. The distance from the impact event is a paramount variable, as such, the orthodromic distance between each 308 municipalities and the impact location needs to be estimated. The orthodromic distance or great-circle distance is the shortest distance between two points on a sphere's surface. Given an angle Δ defined as the angle between 2 interest points around the Earth centre, the orthodromic distance D is given by:

$$D = R_{\text{♁}}\Delta \quad (2.1)$$

where $R_{\text{♁}}$ is the radius of the Earth.

2.2.1 Spherical Triangle

A spherical triangle is a triangle on a sphere whose edges are orthodromies, *i.e.,* they are the smallest arc of the great circle that contains two vertices. A great circle is defined as being the intersection of a sphere and a plane that passes through the sphere's centre. Assuming the Earth as being a 6371-kilometre radius sphere, the orthodromic distance of any two points on the Earth's surface can be obtained. Given a generic spherical triangle, represented in Figure 2.2, the spherical law of cosines is given by the following relation:

$$\cos(a) = \cos(b)\cos(c) + \sin(b)\sin(c)\cos(A) \quad (2.2)$$

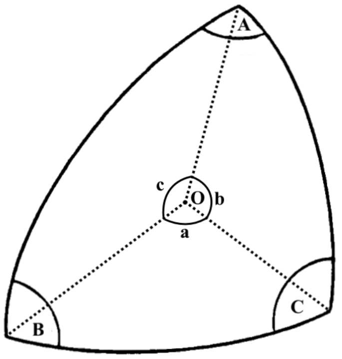

Figure 2.2: Spherical triangle. Modified from [28].

2.2.2 Orthodromic Distances

Assuming that the point O corresponds to the Earth's centre, and that the angles A, B, and C are centred on the North Pole, the impact location, and the municipality, respectively, the central angle a will correspond to the angle Δ that is needed to obtain the orthodromic distance D.

The angle A, the central angles b and c can be written as a function of the geodetic coordinates of both the impact location and the municipality as:

$$\begin{cases} A = |\lambda_i - \lambda_k| \\ b = \frac{\pi}{2} - \phi_k \\ c = \frac{\pi}{2} - \phi_i \end{cases} \qquad (2.3)$$

where ϕ and λ represents the latitude and longitude, and the indexes i and k represent the impact location and the municipality, respectively.

Due to the sine and cosine being directly related, it can be expressed as:

$$\Delta = \arccos\left[\sin\phi_i \sin\phi_k + \cos\phi_i \cos\phi_k \cos\left(|\lambda_i - \lambda_k|\right)\right] \qquad (2.4)$$

Finally, the orthodromic distance D ensues from equations 2.1 and 2.4:

$$D = R_{\text{♁}} \arccos\left[\sin\phi_i \sin\phi_k + \cos\phi_i \cos\phi_k \cos\left(|\lambda_i - \lambda_k|\right)\right] \qquad (2.5)$$

In Table 2.2 are presented the district capitals geodetic coordinates in decimal degrees. The angle Δ and distance D to the impact site are also presented.

Table 2.2: Geodetic Coordinates of key municipalities along with the corresponding angle and distance to the impact site

Municipality	ϕ_k $[deg]$	λ_k $[deg]$	Δ $[rad]$	D $[km]$
Aveiro	40.64	−8.65	0.1123	715.2
Beja	38.02	−7.86	0.1267	807.1
Braga	41.55	−8.42	0.1180	751.6
Bragança	41.81	−6.76	0.1401	892.5
Castelo Branco	39.82	−7.49	0.1270	809.2
Covilhã	40.29	−7.50	0.1269	808.5
Coimbra	40.21	−8.42	0.1147	730.5
Évora	38.57	−7.90	0.1239	789.7
Faro	37.02	−7.93	0.1315	837.9
Funchal	32.63	−16.90	0.1219	776.6
Guarda	40.54	−7.27	0.1303	830.1
Leiria	39.75	−8.80	0.1094	697.2
Lisboa	38.73	−9.13	0.1069	681.3
Ponta Delgada	37.74	−25.67	0.1231	784.5
Portalegre	39.30	−7.43	0.1284	818.0
Porto	41.15	−8.61	0.1140	726.5
Santarém	39.23	−8.68	0.1117	711.4
Setúbal	38.53	−8.90	0.1107	705.3
Viana do Castelo	41.69	−8.83	0.1134	722.5
Vila Real	41.30	−7.74	0.1257	800.9
Viseu	40.66	−7.91	0.1220	777.1

2.3 Asteroid's Impact Properties

Asteroids destructive capabilities depends on the asteroid's diameter, the asteroid's density, the impact angle, but mainly on its impact velocity. The orbital properties of the asteroids were not taken into consideration in the velocity assessment nor any stage of the analysis. No atmosphere model was considered in the impact simulations, nor the atmosphere effect on the impactor. The velocity at which the impactor pierces the Earth's upper atmosphere was assumed the same as the impact velocity. The asteroids dimensions were also assumed to remain unchanged during the atmospheric passage.

2.3.1 Impact Velocity

As the asteroid impact occurs at sea, there are two stages of impact. The first being the impact on the water, at sea level, and the second being the impact on the sea floor following the traversal through the ocean. The velocity at which the asteroid impacts the ocean floor was therefore needed to further assess its effects. Collins *et al.* in [15] provides a rudimentary relation that allows estimating the effect of a water layer on the asteroid's velocity. The equation computes the impactor's velocity at the sea floor, $v_{i_{seafloor}}$, as a function of the impactor's velocity at the surface, $v_{i_{surface}}$, as:

$$v_{i_{seafloor}} = v_{i_{surface}} e^{\frac{3\rho_w C_D h_{sea}}{2\rho_i L \sin\theta}} \quad (2.6)$$

In the foregoing equation, ρ_w and ρ_i are the water and impactor densities, h_{sea} is the ocean floor's depth, L is the impactor's diameter, θ is the impact angle and C_D is the drag coefficient for a rigid sphere in the supersonic regime, which was set to 0.887 by the author. Is worthy of note that the equation does not take into consideration the flattening of the impactor nor the shock wave propagation through the water, as expressed by the author.

2.3.2 Impact Energy

The energy release during an impact event is the most fundamental property in assessing the potential consequences of said event. This energy is intricately related to the kinetic energy of the impactor E, expressed as a function of the impactor velocity, as:

$$E = \frac{1}{2} m_i v_i^2 \quad (2.7)$$

Given the definition of density, the mass can be written as:

$$m = \rho_i V \quad (2.8)$$

Assuming a perfect sphere, the volume V can be expressed, as a function of the diameter L, by:

$$V = \frac{1}{6} \pi L^3 \quad (2.9)$$

Combining the equations 2.8 and 2.9, the energy can be given as:

$$E = \frac{\pi}{12}\rho_i L^3 v_i^2 \quad (2.10)$$

Therefore, by utilizing both impact velocities, $v_{i_{seafloor}}$ and $v_{i_{surface}}$, the impact energy at the surface $E_{surface}$ of the water layer, and consequently at the sea floor $E_{seafloor}$, can be obtained. The air blast and thermal radiation models, explained in detail in sections 2.5 and 2.6, assume that the impact energy that catalyses these effects is released at the surface ($E = E_{surface}$). On the other hand, effects such as seismic shaking and ejecta deposition originate from solid target impacts, thus the impact energy is assumed to be the kinetic energy from the impactor reaching the ocean floor ($E = E_{seafloor}$). These assumptions imply that, in terms of the air blast and thermal radiation, a ground and water impact of the same impact energy are equivalent. However, the presence of a water column could attenuate the seismic shaking intensity and the ejecta released when compared to a ground impact scenario.

2.3.3 Crater Dimensions

The complexity of the cratering process, involving the propagation of shock waves and depression formation through excavation, hamper the crater dimensions modelling. The process can be broken down to two stages, the formation of a transient crater, *i.e.,* an unstable structure that cannot support itself, and its subsequent collapse due to gravity and formation of the final crater. Collins *et al.* in [15] developed, through the usage of scaling laws and

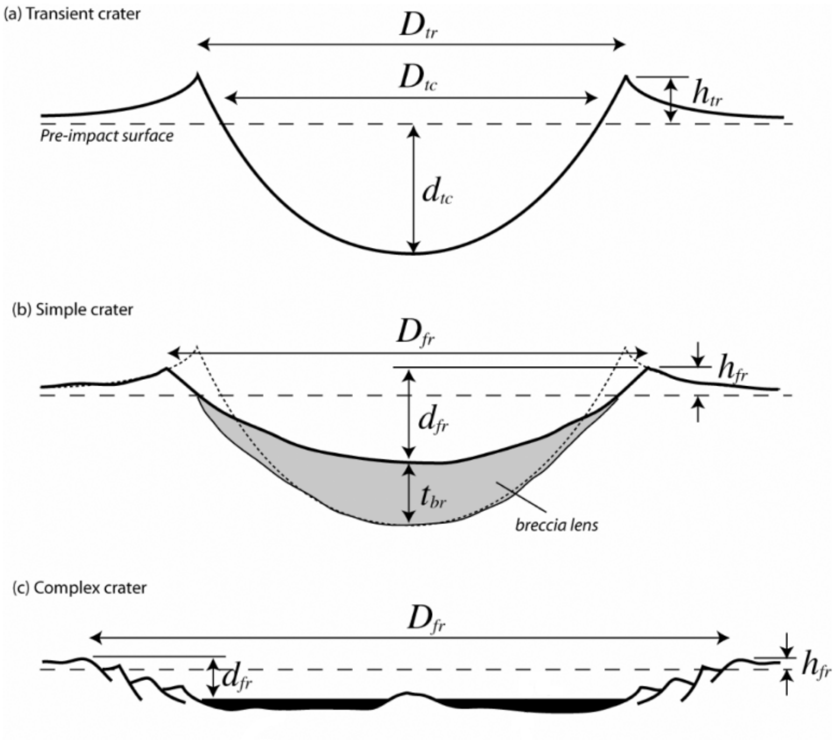

Figure 2.3: Crater dimensions for the transient crater (a), simple (b) and complex final crater (c). Modified from [15].

empirical data, analytical relations to express the crater dimension which were also later presented by Rumpf in [23]. Both transient and final crater are visually represented in Figure 2.3. The latter can be either simple or complex given the size of the former. The following equation expresses the transient crater diameter D_{tc}, in meters, as a function of the initial parameters of the impact, these being the density of the target ρ_t and impactor ρ_i, the impactor's diameter L, the impact velocity v_i, the angle of impact θ and the Earth's standard gravitational acceleration g_0:

$$D_{tc} = 1.161 \left(\frac{\rho_i}{\rho_t}\right)^{1/3} L^{0.78} v_i^{0.44} g_0^{-0.22} \sin^{1/3}\theta \quad (2.11)$$

This equation holds true for impacts on solid surfaces, for instance, the ocean floor. For impacts on liquid bodies, a slight alteration must be considered, altering the constant from 1.161 to 1.365 provided the suited results. The final crater can be further categorized as simple or complex based on its morphology. In terms of crater diameter, the threshold lies on 3.2 km. For simple craters, the final crater diameter, from rim-to-rim, can be expressed as:

$$D_{fr} = 1.25 D_{tc} \quad (2.12)$$

if the transient crater is greater than 2.56 km, the following expression, to obtain the final crater diameter, is used instead:

$$D_{fr} = 1.17 \frac{D_{tc}^{1.13}}{D_c^{0.13}} \quad (2.13)$$

where all three diameters are in km and D_c is the threshold diameter between simple and complex craters, in Earth's case it is 3.2 km. The depth of the transient crater in relation to the original ground plane was given by the following expression:

$$d_{tc} = \frac{D_{tc}}{2\sqrt{2}} \quad (2.14)$$

For the final complex crater, the depth was estimated, in reference [16], by the relation:

$$d_{fr} = 0.294 D_{fr}^{0.301} \quad (2.15)$$

for simple crater, the depth is simply given by:

$$d_{fr} = d_{tc} + h_{fr} - t_{br} \quad (2.16)$$

where h_{fr} and t_{br} are the rim height and the thickness of the breccia lens, given by the following equations 2.17 and 2.18, respectively:

$$h_{fr} = 0.07 \frac{D_{tc}^4}{D_{fr}^3} \quad (2.17)$$

$$t_{br} = 2.8V_{br}\left(\frac{d_{tc} + h_{fr}}{d_{tc}D_{fr}^{2}}\right) \quad (2.18)$$

The unbulked breccia lens volume V_{br} is assumed to be related to the final crater by:

$$V_{br} = 0.032D_{fr}^{3} \quad (2.19)$$

Finally, the volume of the transient crater can be given by:

$$V_{tc} = \frac{\pi D_{tc}^{3}}{16\sqrt{2}} \quad (2.20)$$

2.4 Seismic Shock

Given a ground or ocean floor impact event, a seismic shock is generated that equates to approximately a ten-thousandth of the impactor's kinetic energy. The Gutenberg-Ritcher magnitude energy relation, referenced by Collins in [15] and later by Rumpf in [23], gives us the seismic magnitude of an impactor as a function of its kinetic energy:

$$M = 0.67\log_{10}E - 5.87 \quad (2.21)$$

where E is the kinetic energy in Joules and M the magnitude on the Ritcher scale. The seismic intensity decays over the travelled distance. The effective magnitude M_{eff} of the seismic shock on a specific location, at a distance D, was expressed by Collins in [15] and later by Rumpf in [23] as:

$$M_{eff} = \begin{cases} M - 2.38\times10^{-5}D & : D < 60\,000\;m \\ M - 4.8\times10^{-6}D - 1.1644 & : 60\,000\;m \leq D < 700\,000\;m \\ M - 1.66\log_{10}\Delta - 6.399 & : 700\,000\;m \leq D \end{cases} \quad (2.22)$$

where Δ is the angle in radians between the impact and relevant location with the Earth's centre as its apex, defined in equation 2.4. The three-equation defined function is represented in Figure 2.4. In the graphical representation it can be observed the effective magnitude M_{eff} decay over the distance D for any given magnitude at the impact location M. Given the present relation of the seismic magnitude it is possible to obtain negative values, which do not have any physical significance. For example, for a magnitude $M = 3$, at $500\;km$ onwards we would have increasing negative values. It is also clear the presence of a discontinuous point for $D = 700\;km$, where the function M_{eff} changes equations.

Collins *et al.* in [15] provided a means to compute the arrival time of the seismic waves T_s by using $5\,000\;m/s$ as the typical wave velocity on upper-crustal rocks, through the simple relation:

$$T_s = \frac{D}{5000} \quad (2.23)$$

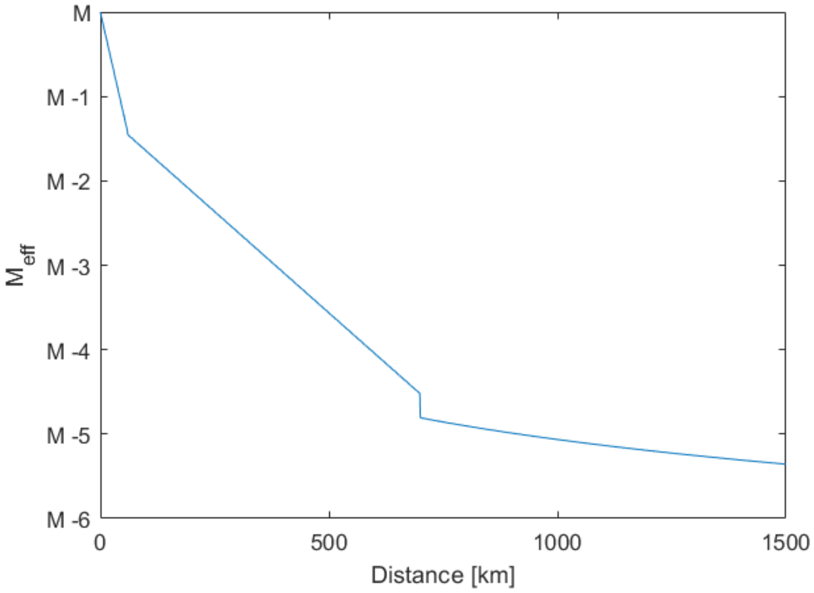

Figure 2.4: Effective magnitude as a function of the impact site distance for a given seismic magnitude M.

2.5 Air Blast

Asteroid impact events, like explosions, create air blasts, shock waves that increases the atmospheric pressure at the vanguard. Relying on yield scaling, the distance D_1 that experiences the same peak overpressure from a 1 kt energy impact as the distance D experiences from an E_{kt} energy impact can be found. The yield scaled distance D_1 is given by:

$$D_1 = \frac{D}{E_{kt}^{1/3}} \quad (2.24)$$

where D is the distance from the impact location and E_{kt} is the yield energy in kilotons TNT. The decay of the peak overpressure in Pa as a function of the yield scaled distance can be modelled as:

$$p_D = \frac{p_x D_x}{4D_1}\left(1 + 3\left[\frac{D_x}{D_1}\right]^{1.3}\right) \quad (2.25)$$

where the values p_x and D_x that Collins *et al.* in [15] found to best fit the empirical data provided by the US nuclear explosion tests were $75\ 000\ Pa$ and $290\ m$, respectively. The fore-mentioned equation 2.25 can be observed graphically in Figure 2.5. Represented on a logarithmic scale the pressure decay over the yield-scaled distance D_1 is evident.

Considering that the shock wave vanguard travels through the air at the ambient sound speed a_0, approximately equal to $343\ m/s$, it's also possible to obtain the air blast arrival time at a particular distance D from the impact location:

$$T_b = \frac{D}{a_0} \quad (2.26)$$

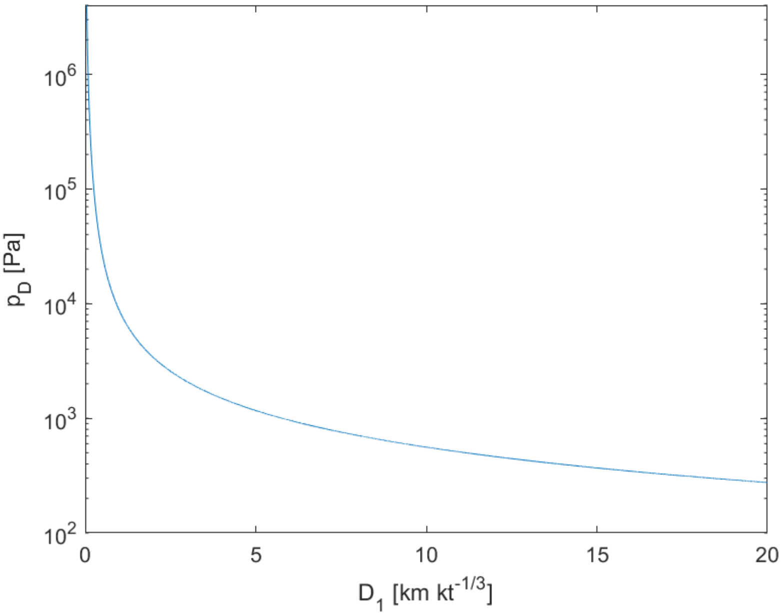

Figure 2.5: Peak overpressure as a function of the yield scaled distance D_1.

2.6 Thermal Radiation

In the surroundings of an impact site, the temperature and pressure are drastically raised during an impact event. Collins in [15] and later Rumpf in [23] is presented a means to evaluate and compute the thermal energy emanated from an impact event. For impact velocities greater than 12 km/s, the shock pressure can melt the impactor and some target material; for velocities greater than 15 km/s, vaporization begins to occur. The vapour generated has very high pressure and temperatures that expand rapidly, a process named fireball. This thermal radiation model neglects the effect of atmospheric conditions and the variation in atmospheric absorption with altitude above the horizon. The empirical relation between the radius of the fireball R_f in meters and the impact energy E in Joules is:

$$R_f = 0.002E^{1/3} \quad (2.27)$$

The thermal radiation is only a fraction of the kinetic energy released during an impact. This fraction, the luminous efficiency η_{lum}, for asteroid impacts with Earth is presently in the range of $10^{-4} - 10^{-2}$, a range found through limited experimental and numerical results [15]. The thermal energy per area unit is given by:

$$\phi = f\frac{\eta_{lum}E}{2\pi D^2} \quad (2.28)$$

where f is the fraction of visible fireball over the horizon at distance D, obtained by:

$$f = \frac{2}{\pi}\left(\cos^{-1}\frac{h}{R_f} - \frac{h}{R_f}\sin\left[\cos^{-1}\frac{h}{R_f}\right]\right) \quad (2.29)$$

In this equation, h is the maximum height of the fireball below the horizon at a distance D, it is defined as:

$$h = (1 - \cos\Delta)\, R_{\text{♁}} \quad (2.30)$$

where Δ is the angle defined in equation 2.4. If $h \geq R_f$ then, the fireball is entirely below the horizon, which means that there is no direct thermal radiation reaching the location in question. So, if such scenario becomes a reality there will not be results and the thermal radiation of the below the horizon locations will be zero, this statement can be verified through the following Figures 2.6 and 2.7.

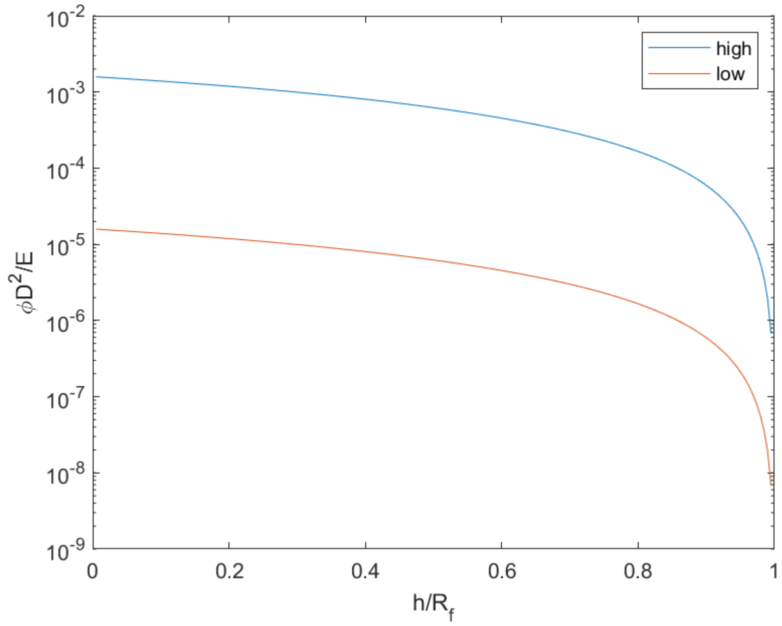

Figure 2.6: Thermal radiation times the squared distances over the impact energy $\phi D^2/E$ as a function of the fireball maximum height below the horizon over the radius of the fireball h/R_f, both given the high and low range limits of the luminous efficiency η_{lum}.

The visual depictions of the thermal radiation model were made so that the radiation on a given place would be independent of the total impact energy. Two unnamed variables emerged, the thermal radiation times the squared distances over the impact energy $\phi D^2/E$ and the thermal radiation over the fireball radius squared. With both representation it can be seen the constant radiance near the impact site and the abrupt decay as the maximum height of the fireball below the horizon h approaches the radius of the fireball R_f. This supports the claim that the thermal radiation originated from an asteroid impact is intense in the surroundings of the impact site but decays rapidly. These observations are made neglecting any kind of atmospheric reflection.

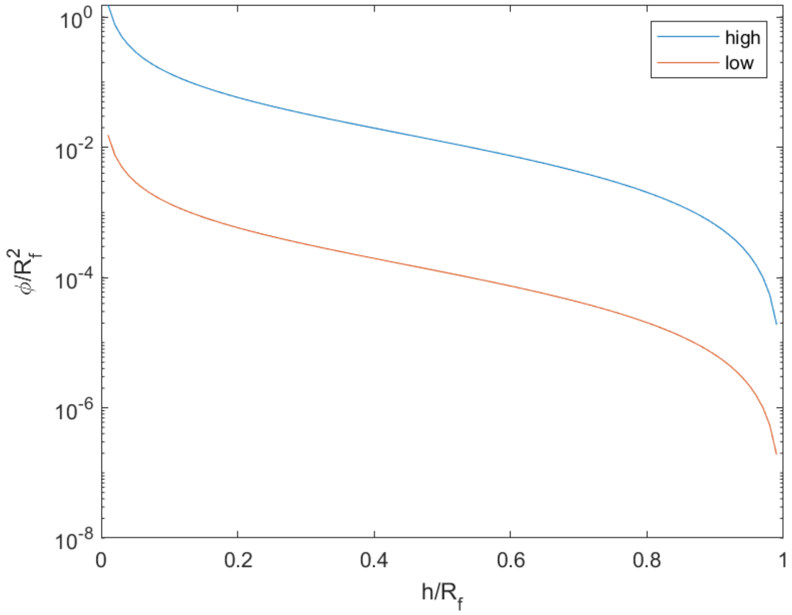

Figure 2.7: Thermal radiation over the fireball radius squared as a function of the fireball maximum height below the horizon over the radius of the fireball h/R_f, both given the high and low range limits of the luminous efficiency η_{lum}.

2.7 Ejecta Deposit

The ejection of material from the impact site is one of the aftermaths of a solid ground collision. This ejected material, named ejecta, can endanger populations by landing directly on civilized areas, by forming a blanket of dense particles that covers the surroundings, or by damaging infrastructures, such as buildings or bridges, to the point of collapse by deposition, or by direct collision. Collins *et al.* in [15] deduced analytical equations to estimate the mean ejecta fragment diameter and the ejecta blanket thickness that were later exposed by Rumpf in [23]. The mean ejecta fragment diameter L_e, in meters, can be given, as a function of the final crater diameter D_{fr} and distance D, by:

$$L_e = 2400 \left(\frac{D_{fr}}{2000}\right)^{-1.62} \left(\frac{D_{fr}}{2D}\right)^{2.65} \qquad (2.31)$$

The ejecta blanket thickness t_e as a function of the transient crater diameter D_{tc} and the distance D is expressed as:

$$t_e = \frac{D_{tc}^4}{112D^3} \qquad (2.32)$$

Collins *et al.*, also in [15], presented an approach to estimate the ejecta velocity, *i.e.*, the required ejection velocity for a particular ejecta fragment to reach the location in question, and the ejecta arrival time. To compute the ejection velocity the following relation is used:

$$v_e^2 = \frac{2g_0 R_{♁} \tan \Delta/2}{1 + \tan \Delta/2} \qquad (2.33)$$

For the ejecta arrival time, assuming an ejection angle of 45°, a more complex analytical expression is needed:

$$T_e = \frac{2a^{1.5}}{\sqrt{g_0 R_\oplus^2}} \left[2\tan^{-1}\left(\sqrt{\frac{1-e}{1+e}} \tan\frac{\Delta}{4} \right) - \left(\frac{e\sqrt{1-e^2}\sin(\Delta/2)}{1+e\cos(\Delta/2)} \right) \right] \quad (2.34)$$

where the previously unmentioned variables a and e are the semi-major axis and ellipticity of the trajectory of ejecta leaving the impact site at a 45° angle, given by:

$$a = \frac{v_e^2}{2g_0\left(1-e^2\right)} \quad (2.35)$$

$$e = \sqrt{\frac{1}{2}\left[\left(\frac{v_e^2}{g_0 R_\oplus} - 1 \right)^2 + 1 \right]} \quad (2.36)$$

Both equations 2.31 and 2.32 are represented in Figures 2.8 and 2.9, via semi-logarithmic scales. The mean ejecta fragment diameter and the ejecta blanket thickness are represented independently of the final crater diameter formed in the collision and as a function of the distance. The immense effect attenuation over the distance is clear, as several orders of magnitude are lost in the first 500 kilometres. This model does not take into consideration the atmospheric effects in the transport of particles.

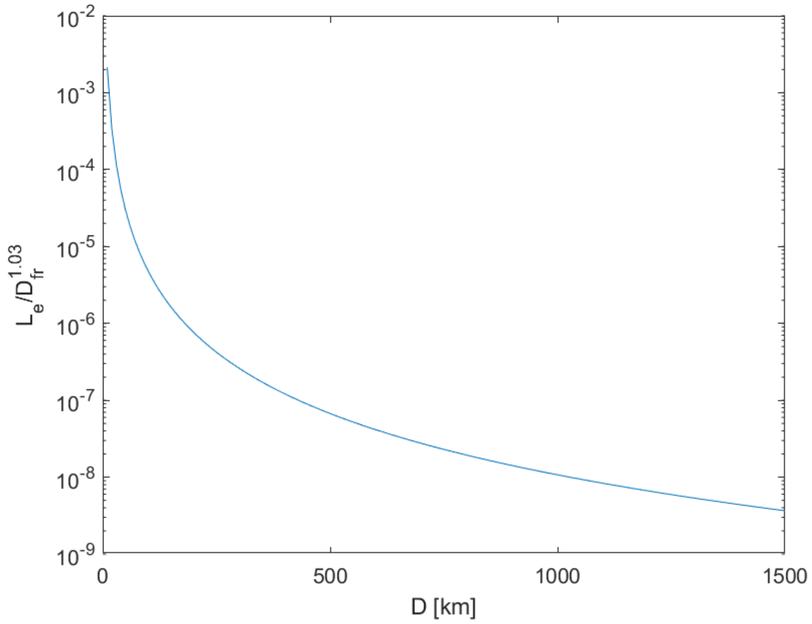

Figure 2.8: Mean ejecta fragment diameter over the final transient crater diameter $L_e/D_{fr}^{1.03}$ as a function of the distance D.

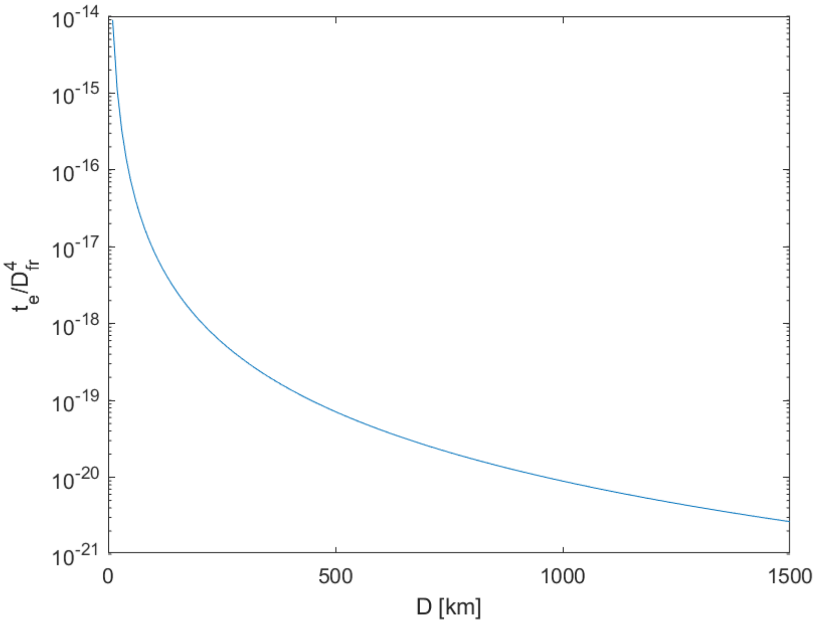

Figure 2.9: Ejecta blanket thickness over the final transient crater diameter to the fourth power L_e/D_{fr}^4 as a function of the distance D.

2.8 Tsunami

Following an asteroid impact on a water surface, a circular wave pattern is generated, like a droplet impacting a liquid film. These waves can reach tremendous heights and reach habited coastal regions, causing devastation in its wake. This is named tsunami; it is a complex process and a hard effect to model. Rumpf in [23] developed a simple analytical model to assess the wave amplitude propagation $A(D)$ along with the run-up estimation U. The author's tsunami models were further simplified here to cover the lack of complex input variables required. These variables include the ocean bathymetry and the coast orography as well as the coastline geometry and configuration. The tsunami model henceforth presented is mainly based on Rumpf's wave amplitude attenuation and run-up estimation methods. However, the work of authors like Collins and Melosh and Wünnemann *et al.* have new intakes on the same problems and their wave amplitude attenuation methods were used to compare and complement the pre-established model.

The tsunami assessment can be divided in two phases: the deep-water wave propagation, and the wave run-up near the coast. The wave amplitude attenuation models estimate the evolution of the maximum wave amplitude in deep-waters, which assumes a constant ocean depth. In the threshold point between deep and shallow waters, assumed to be where the ocean is 800 metres deep, the wave amplitude value is then calculated. In shallow waters, the model estimates the run-up wave evolution until it reaches the coast, given the initial threshold wave amplitude, and assumes the ocean floor has a positive slope.

Despite the multiple researches already performed in this field, the understanding of oceanic impacts still remains incomplete and incongruous between authors. The difference between classical tsunami waves produced by earthquakes and waves produced by asteroid impacts is an established veracity, but the impact-generated tsunamis hazard is still a questionable paradigm.

2.8.1 Rim-wave

The initial impact on the ocean surface radially displaces the water to create the surface transient crater. This displacement is the origin of the wave perturbation that eventually develops into the first tsunami wave, the rim-wave.

According to Rumpf the wave amplitude propagation, as a function of the transient crater diameter D_{tc} and distance D, was defined as:

$$A(D) = \min(0.14D_{tc}, h_{sea}) \left(\frac{D_{tc}}{2D}\right) \quad (2.37)$$

Collins and Melosh in [16] also developed a rim wave amplitude propagation model. Both models present a wave decay with radial distance as $1/D$ which is in accordance with oceanic impact simulations [17]. The rim-wave maximum amplitude was defined as:

$$A_{rw}^{max} = \min\left(\frac{D_{tc}}{14.1}, h_{sea}\right) \quad (2.38)$$

The rim-wave amplitude A_{rw} at a distance D from the impact location was estimated as:

$$A_{rw} = A_{rw}^{max}\left(\frac{3D_{tc}}{4D}\right) \quad (2.39)$$

The representation of both wave amplitude propagation models is presented in Figure 2.10 in graphical form. It is independent of the transient crater diameter on the water surface and assumes that the amplitude cannot be larger than the depth of the water layer. Collins and Melosh in [16] states that this type of waves are generated for any oceanic impact. Wünnemann *et al.* in [17] adds that even though rim-waves are always generated for deep ocean impacts the wave decays almost immediately and can be neglected.

2.8.2 Collapse-waves

The second type of wave are a product of the surface transient crater collapse, hence the name, collapse wave. The impact-induced surface transient crater gets filled by the adjacent ocean through centripetal inflow. The radial inflow creates a water peak at the centre of the now-collapsing crater that will continue to oscillate radially in and out until all energy is dissipated. Each oscillation generates a collapse wave. However, in the model being exhibited, the formation of the collapse wave is assumed unique and unrepeatable.

A collapse wave is only generated if the ocean depth is more than twice the impactor diameter $h_{sea} < 2L$, and Wünnemann *et al.* states that this type of wave is the predominant wave

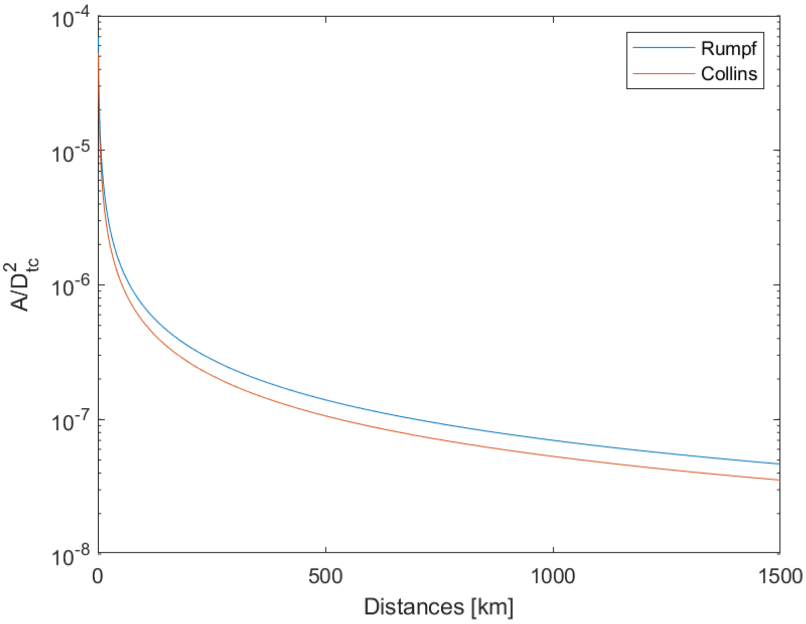

Figure 2.10: Wave amplitude over the transient crater diameter squared A/D_{tc}^2 as a function of the distance D.

formed in deep ocean impacts. In [16], Collins and Melosh defined a model to predict the collapse wave amplitude decay over the distance. The maximum collapse wave amplitude was given by:

$$A_{cw}^{max} = 0.06\ min\left(\frac{D_{tc}}{2.828}, h_{sea}\right) \quad (2.40)$$

The collapse wave amplitude decay as a function of the distance D was defined as:

$$A_{cw} = A_{cw}^{max}\left(\frac{5D_{tc}}{2D}\right)^q \quad (2.41)$$

where q is the attenuation factor, defined as:

$$q = 3e^{-0.8L/h_{sea}} \text{ for } L/h_{sea} < 0.5 \quad (2.42)$$

Theoretically, if the attenuation factor of the collapse wave was $q = 1$, the collapse wave would decay equally with the rim-wave over distances. For $q > 1$ the collapse wave would decay faster, given the $1/D^q$ decay versus the $1/D$ rim-wave decay. On the other hand, for $q < 1$ the collapse wave decay would be slower in comparison with the rim-wave. However, the $L/h_{sea} < 0.5$ restriction limits the attenuation factor range between 2 and 3, which means the collapse wave will always decay faster than the rim-wave. This comparison is true over large distances. The wave amplitude behaviour close to the impact site could, and most likely would, differ from the statements made.

The distance-wise attenuation differences between the collapse wave and rim-wave amplitudes depend on various factors. In Figure 2.11, a visual representation of the tsunami wave amplitudes as a function of the distance to the impact site and the asteroid's diameter can be seen. This plot assumes that the ocean depth at the impact site remains constant at $4910\ m$. In Figure 2.12 a top side view from the previous mentioned plot is shown. The colour coding distinguishes both wave amplitude methods and in the top view represents which tsunami wave exhibits the highest amplitude value for a given distance D and diameter L pair.

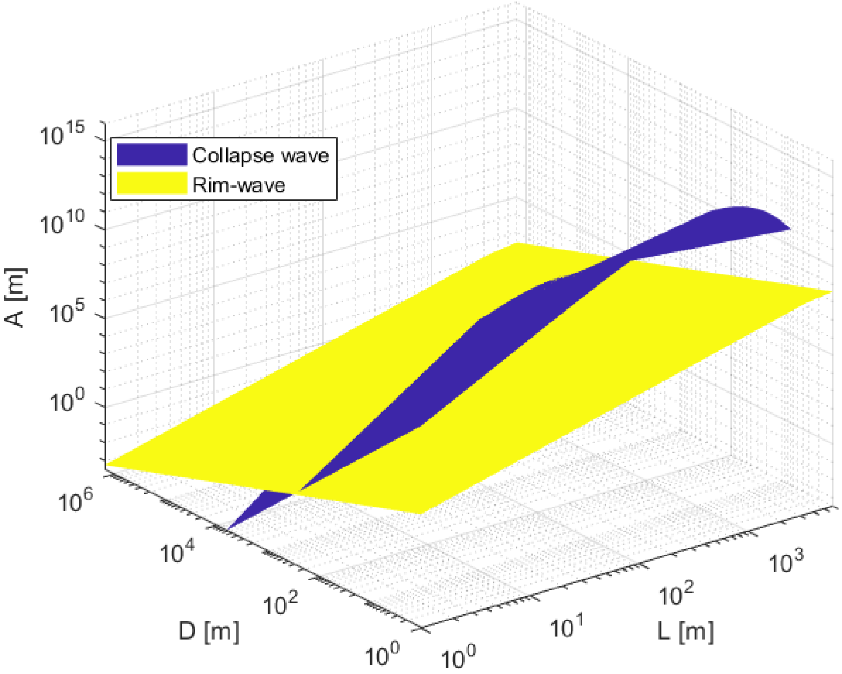

Figure 2.11: Amplitude A comparison between the collapse wave and rim-wave with varying distance to the impact site D and asteroid diameter L.

All three axis are represented on a logarithmic scale. This non-linear scale might induce the misperception of the predominant wave amplitude. The collapse wave appears to entail the highest amplitude values throughout the domain. There is a direct correlation between the highest amplitude values and the greater tsunami threats. Upon further examination the collapse wave amplitude only predominates over the rim wave amplitude for shorter distances independent of asteroid size. For a kilometre-wide impactor, the collapse wave threat is only greater until the low dozens of kilometres from the impact site. So, for the analysis in the present work, the greatest tsunami wave threat is the rim-wave, given that the locations to be studied are a few hundreds of kilometres from the impact site. The collapse wave amplitude values end abruptly upon reaching an asteroid's diameter of $h_{sea}/2$, this is due to the assumption made that collapse waves are only formed in oceanic impacts by an asteroid less than half the depth.

2.8.3 Run-up

The wave run-up U was defined as the reach of the wave in terms of height, *i.e.*, the maximum vertical extent of a wave, given the slope s of the coastal region. The following expression as used for its computation:

$$U = 2sA_{800}\left(\frac{A_{800}}{D_{tc}}\right)^{-0.5} \qquad (2.43)$$

where A_{800} is the wave amplitude when it reaches shallow water, defined as being depths less than 800 m. The shore slope s was simply defined by the slope formula, commonly known as rise over run formula:

$$s = \frac{|h_{800} - h_k|}{D_{shore}} \qquad (2.44)$$

where D_{shore} is the distance from the 800 m depth point to the location, h_{800} is per definition $-800\ m$ and h_k is the altitude of the location.

It is worth reiterating and expanding the exposition of the simplifications made assessing the amplitude and run-up waves. Every location was assumed to be in line of sight of the tsunami origin, *i.e.,* the ocean waves interference and reflection patterns were not considered, as well as the topographic and bathymetric features. The only particular feature considered was the perpendicular distance from the coast to the ocean point with an 800 m depth. The southern continental Portuguese coast is a good example to illustrate the simplifications made. This area is not facing the impact point and assessing the tsunami wave reaching the coast would be far too complex, as an alternative, the tsunami wave was assumed to be coming from the south.

The problem with this model is that it only assesses the run-up for coastal regions. Rumpf developed a method to evaluate the run-up development inland by dividing all the affected area

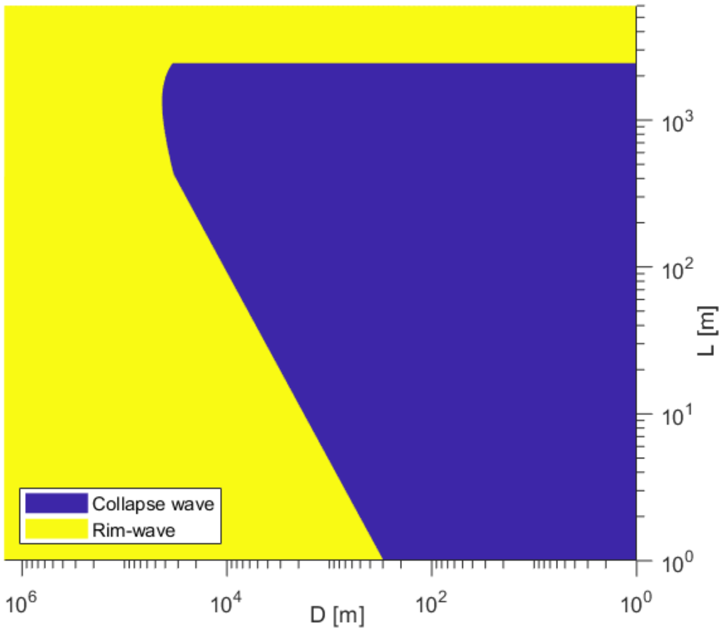

Figure 2.12: Amplitude A comparison between the collapse wave and rim-wave with varying distance to the impact site D and asteroid diameter L, top view.

in pixels and computing a local run-up by comparing the run-up with the pixel's maximum height. However, in this work, there is no way to interconnect the individual municipalities. It is not possible to predict the tsunami wave in that extent, claiming that the wave with a run-up U will hit municipality k followed by municipality j. To counter this uncertainty a new method to access every desired municipality was developed.

For every location, the maximum and minimum slope was obtained by inserting the maximum $h_{k_{max}}$ and minimum $h_{k_{min}}$ altitude in equation 2.44. With these two new variables the maximum run-up U_{max} and the minimum run-up U_{max} was computed. However, even if the slope considers the elevation of the location, the run-up is in relation to the sea level. Thus, to assess what can be called a local run-up U_l the minimum altitude of the location must be taken into consideration:

$$U_l = U - h_{k_{min}} \quad (2.45)$$

Once again, this local run-up can be defined with the maximum run-up, resulting in a maximum local run-up; or, on the other hand, with the minimum run-up. Throughout this work, and more specifically in the tsunami modulation, the locations are treated as points with a particular set of coordinates. Consequently, all the variables dependant of the minimum and maximum altitude of a location are obtained assuming the hypothetical nature of a location point with two different applicates values, the minimum and maximum altitudes.

2.8.4 Tsunami-waves arrival time

Collins and Melosh in [16] also developed maximum and minimum estimate for the tsunami waves arrival time. The author states the uncertainty intrinsic to these estimations before presenting the minimum and maximum arrival time as a function of the distance travelled D as:

$$T_w^{min} = \frac{D}{min\left(\sqrt{1.56D_{tc}\left(1+39.5\left(\frac{A^{max}}{D_{tc}}\right)^2\right)}, \sqrt{9.8h_{sea}}\left(1+\frac{A^{max}}{2h_{sea}}\right)\right)} \quad (2.46)$$

$$T_w^{max} = \frac{D}{\sqrt{1.56D_{tc}\tanh\left(\frac{6.28h_{sea}}{D_{tc}}\right)}} \quad (2.47)$$

where A^{max} is the maximum amplitude of the collapse or rim wave.

2.9 Global Effects

To conclude the impact effect analysis, the possible global effects were taken into consideration. Collins *et al.* in [15] presented a simple way to assess the global effect by computing the linear and angular momentum ratios between the Earth and the impactor and also the volume ratio of the transient crater diameter and the Earth's volume.

The linear momentum of the impactor M_i can be obtained by relating its mass m_i and its impact velocity v_i:

$$M_i = m_i v_i \quad (2.48)$$

Earth's linear momentum is obtained in a similar way, assuming its mass being $m_{♁} = 5.83 \times 10^{24}\ kg$ and its mean orbital velocity $v_{♁} = 29780\ m/s$. The angular momentum of the impactor is obtained by:

$$\mathit{\Gamma}_i = m_i v_i R_{♁} \cos\theta \quad (2.49)$$

whilst the Earth's angular momentum was assumed to be $\mathit{\Gamma}_{♁} = 5.86 \times 10^{33}\ kg\ m^3\ s^{-1}$. The volume of the Earth was obtained assuming a 6371 km radius sphere. Depending on the three ratios mentioned, the qualitative global implications of a given impact can be observed in Table 2.3.

Table 2.3: Global implications of an impact event [15]

Ratio	Interval	Qualitative global change
$M_i/M_{♁}$	$]$-$\infty; 0.001[$	No noticeable change in orbit.
	$]0.001; 0.01[$	Noticeable change in orbit.
	$]0.01; 0.1[$	Substantial change in orbit.
	$]0.1; +\infty[$	Totally changes orbit.
$\Gamma_i/\Gamma_{♁}$	$]$-$\infty; 0.01[$	No noticeable change in rotation period and tilt of axis.
	$]0.01; 0.1[$	Noticeable change in rotation period and tilt of axis.
	$]0.1; 1.0[$	Substantial change in rotation period and tilt of axis.
	$]1.0; +\infty[$	Totally changes rotation period and tilt of axis.
$V_{tc}/V_{♁}$	$]$-$\infty; 0.1[$	Earth is not strongly disturbed and loses negligible mass.
	$]0.1; 0.5[$	Earth is strongly disrupted but loses a little mass.
	$]0.5; +\infty[$	Earth is completely disrupted and loses all mass.

Collins and Melosh in [16] exposed a way to assess the change in the length of a day caused by impacts on Earth. The variation of the Earth's rotation period $\Delta T_{♁}$ can be obtained relating the asteroid's mass m_i, velocity v_i and impact angle θ with Earth's radius $R_{♁}$, mass $M_{♁}$ and rotation period $T_{♁}$, through:

$$\Delta T_{♁} = \frac{5}{4\pi R_{♁}} \frac{m_i}{M_{♁}} \cos\theta\ v_i T_{♁}^2 \quad (2.50)$$

Note that the impact velocity in this equation is the impact velocity in the ocean floor and not in the water layer.

Chapter 3

Vulnerability Models

The vulnerability models estimate the rate of population lethally harmed by an asteroid impact. Vulnerability is intrinsically related to the severity of the impact effects, which in turn are a function of the distance. As a rule of thumb, the effects are more severe in the vicinity of the impact site and its influence attenuates with the increasing distance to the impact site. The sheltered population percentage is a major factor in defining the vulnerability of a population, if a significant part of the population is safeguarded against an effect by being home, for instance, the vulnerability will be lowered. This predicament is dependent on the time of day the impact event occurs, which these models do not take into consideration. These models also fail to take into consideration the terrain orography, the meteorological conditions, the wind's direction, and it is assumed the population has no previous warning about the threat.

The models presented here are non-linear, they are represented through sigmoid logistic functions. Since the models do not account for time-dependent changes they are time-invariant and considered static models. All the following relations displayed are explicit and continuous equations. These vulnerability models are deterministic and will produce the same results given the same initial conditions. The models are also independent of one another, *i.e.*, the total vulnerability of a given location it is not the sum of all individual effect's vulnerabilities. The different model coefficients present throughout this chapter, defined with letters a, b and c, were obtained directly from the work of Rumpf *et al.* in [25], which in turn were estimated via experimental and concrete data.

3.1 Seismic Shaking

To properly relate, at a given distance, the seismic shaking intensity with the mortality rate; Rumpf *et al.* in [25] conducted a literature review to collect relevant data that concluded with a deduction of a seismic shaking vulnerability model. The variability in vulnerability data set was ample, which allowed for a reasonable establishment of the best and worst-case scenario, along with an expected case. The logistic equation relates the seismic intensity on the Ritcher scale, on a given place, with the population vulnerability to that event. The equation representing the three cases are:

$$V_{\text{seis}} = \frac{1}{1 + e^{a\left(M_{eff}+b\right)}} \quad (3.1)$$

where a and b are coefficients defined in Table 3.1 for each one of the three case scenarios.

Table 3.1: Seismic shaking vulnerability coefficients

	a	b
best	-2.51	-9.59
expected	-2.52	-8.69
worst	-3.80	-7.60

All vulnerability models are represented graphically in Figure 3.1. The domain lies between 4 and 12, however, the expected and worst-case scenario functions intersect at $M_{eff} = 5.5$ which changes the terminology for the lesser domain values. The best- and worst-case scenario function also intersect themselves at $M_{eff} = 3.7$ but this value lies beyond the domain where the vulnerability is zero.

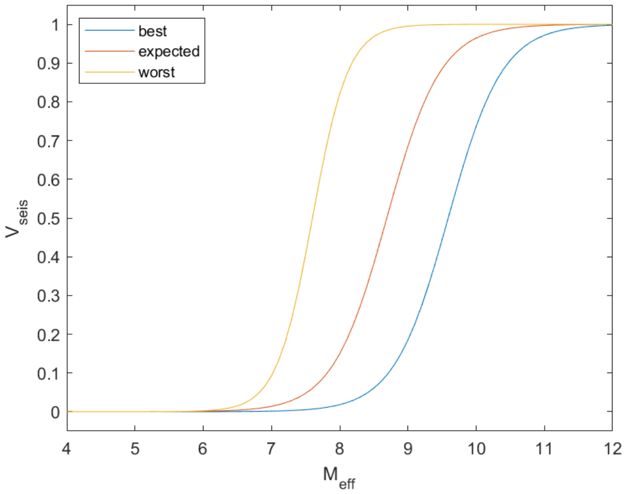

Figure 3.1: Best, worst, and expected case seismic shaking vulnerability models.

3.2 Overpressure

High internal-external body pressure differentials endanger the population. Rumpf *et al.* in [25] utilized data that provided information about non-lethal, half-lethal and entirely lethal pressure differentials to extrapolate the vulnerability models. With the bounding pressure values for each lethal measure, best, worst and expected pressure vulnerability models were developed. However, this model does not take into consideration the damage done to infrastructures and its potential effect on the population. In Figure 3.2 the vulnerability cases and the data are presented. The vulnerability models as logistic functions are as follows:

$$V_{\mathrm{p}} = \frac{1}{1+e^{a(p+b)}} \quad (3.2)$$

where the coefficients a and b are defined in Table 3.2.

The overpressure model has some terminology concerns which might induce some degree of misperception within the first pressure values of the domain. In Figure 3.2 the pressure

Table 3.2: Overpressure vulnerability coefficients

	$a \times 10^5$	$b \times 10^{-5}$
best	-1.90	-5.43
expected	-2.42	-4.40
worst	-2.85	-3.53

domain ranges from 0 to $900\ kPa$. The worst case scenario function intersects the best-case scenario function at $p_D \approx 28\ kPa$ and again the expected one at $p_D \approx 151\ kPa$ from which the scenarios stay true to their denomination for the entirety of the domain model. By contrast these intersections mean that prior to these pressure values the worst-case scenario has the lesser vulnerability values for a given pressure, making it, by definition, the best case scenario. In short, the terminology of the model for pressure values close to zero loses its significance and the vulnerability should be assessed accordingly.

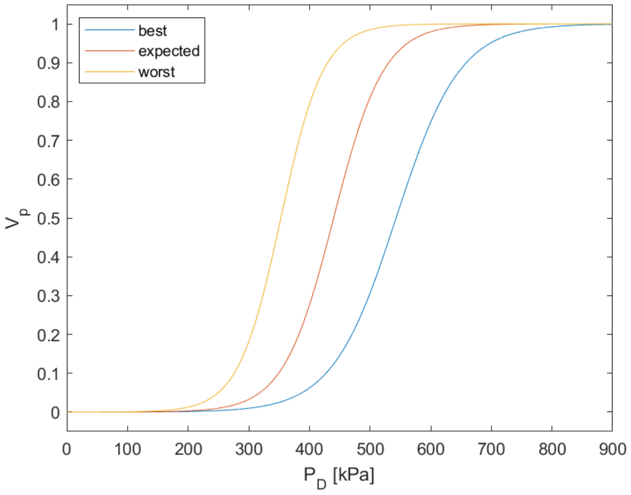

Figure 3.2: Best, worst, and expected case overpressure vulnerability models.

3.3 Thermal Radiation

Thermal radiation can burn or ignite a surface that it encounters. This includes the skin and therefore thermal radiation can be fatal to the populations. Rumpf *et al.* in [25] assembled different kinds of relevant data to develop a thermal radiation vulnerability model. These data included the skin burn probability, the burn degree distribution as a function of the radiation exposure, and the mortality rate of treated and untreated burn victims in function of burnt total body surface area. To obtain the mortality rate as a function of radiant exposure, the author also took into consideration that clothes offer some protection and that only one person's side is exposed to radiation. Finally, to develop the different cases' vulnerability models, the author considered the global unsheltered population at any given moment. For the best-case scenario, all population is sheltered but 25% are affected via windows, for the expected case, the author assumed 47% of unsheltered population. In the worst-case scenario, all population is assumed to be exposed. The vulnerability model is given by:

$$V_\phi = \frac{a}{1 + e^{b(\phi + c)}} \quad (3.3)$$

The respective coefficients are presented in Table 3.3.

Table 3.3: Thermal radiation vulnerability coefficients

	a	$b \times 10^6$	$c \times 10^{-5}$
best	0.25	−5.62	−7.32
expected	0.47	−5.62	−7.32
worst	1.00	−5.62	−7.32

All three thermal exposure vulnerability models are shown in Figure 3.3, where the best, expected and worst-case scenario terminology stays true throughout the domain of the model. For our specific case scenario, the global unsheltered population percentage is of no importance, however, we can use these vulnerabilities functions to assess the casualties due to thermal exposure. If we know the Portuguese unsheltered population at any given hour of the day, we can deduce a vulnerability model depending on the time a day the impact occurs.

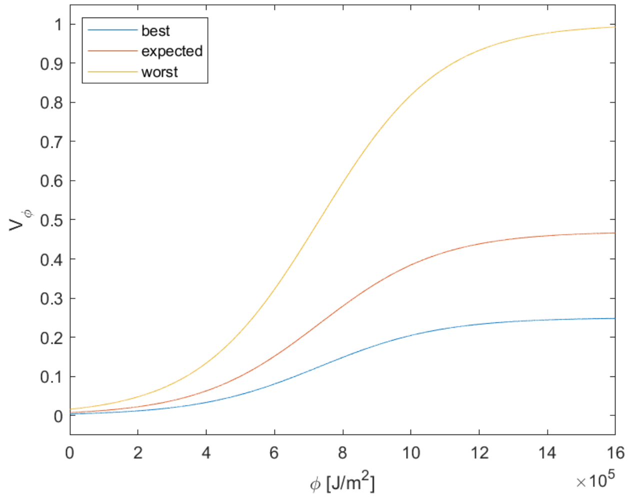

Figure 3.3: Best, worst, and expected case thermal radiation vulnerability models.

3.4 Ejecta Blanket Deposition

The ejected material, product of a ground impact, is a hazard to populations because its deposition can lead to the collapse of buildings due to the ejecta blanket weight load. The ejecta can also bludgeon individuals and cause fatalities. Nonetheless, the latter peril is not included in this vulnerability model. Rumpf in [23] developed a model that relates the ejecta blanket thickness t_e, obtained in Section 2.7 through equation 2.32, to the vulnerability of a predetermined location. The author assumed a mean ejecta material density ρ_e of

$1600\ kg\ m^{-3}$ to assess the load of the ejecta blanket, given by:

$$p_e = t_e \rho_e g_0 \quad (3.4)$$

The author also assumed that 78% of the affected population are indoors and claims, through viable sources, that 20% of a house occupants would be trapped inside, given a collapse, and that 50% of those trapped would be fatalities. Thus, in a roof collapse event, the maximum population vulnerability is $0.78 \times 0.2 \times 0.5 = 0.078$. This vulnerability value is, as previously mentioned, assuming a roof collapse. The occurrence likelihood of this event was modelled considering the ejecta load as well as building strength. Thus, the best, expected, and worst-case scenarios derive from different building strengths. In the best scenario all population are sheltered in strong buildings, whilst in the worst scenario they are sheltered in weak buildings. The sigmoid obtained through the preceding approaches was:

$$V_e = \frac{0.078}{\left[1 + e^{a(p_e+b)}\right]^c} \quad (3.5)$$

where the ejecta load p_e is in kPa. In turn, the coefficients a, b, and c vary depending on the case scenario are presented in Table 3.4. Figure 3.4 represents all three vulnerability cases. As the previous models, the ejecta blanket thickness model also carries some potential misleading aspects. All three function bisect themselves, and its only at $t_e \approx 0.089$ that each vulnerability value, for a given effect value, start to correspond to the respective best, expected or worst-case scenario. So, for ejecta blanket thickness values close to zero the vulnerability can be assessed but with this consideration in mind.

Table 3.4: Ejecta blanket deposition vulnerability coefficients

	a	b	c
best	-1.00	-5.84	-2.58
expected	-1.37	-3.14	-4.60
worst	-4.32	-1.61	-4.13

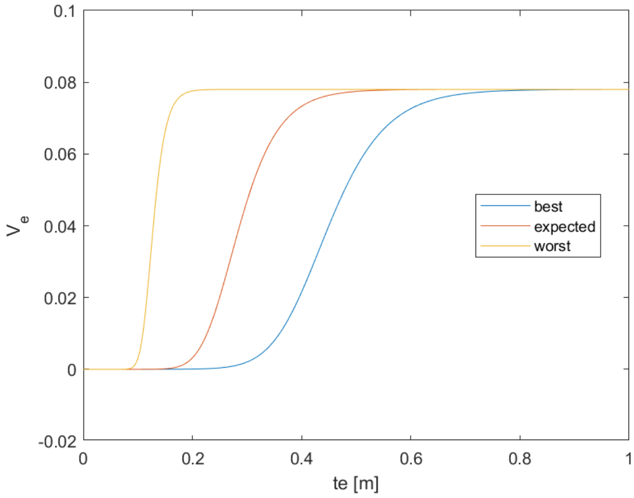

Figure 3.4: Best, worst, and expected case ejecta blanket deposition vulnerability models.

3.5 Tsunami

A large body of water in a waveform can be devastating when hitting a habited coastal region. History corroborates this statement; one example is the tsunami following the 1755 Lisbon earthquake caused massive destruction on the city. Emulating the aftermath of this impact effect is no easy task, once again due to is high complexity and dependence on a variety of external factors. Rumpf *et al.* in [25] developed a simple analytical approach to the analysis of the tsunami wave and its subsequent fatalities. Here it is presented a simple vulnerability computation as a function of the local run-up wave U_l of each municipality. For each case-scenario the local run-up was defined differently, Table 3.5. The relation used was defined as:

$$V_{tsu} = \frac{1}{1 + e^{a(U_l+b)}} \quad (3.6)$$

while its coefficients are defined in Table 3.5 and the visual representation in Figure 3.5.

Table 3.5: Tsunami vulnerability coefficients

	$a \times 10^1$	$b \times 10^{-1}$	U_l
best	-4.53	-1.21	$U_{min} - h_{k_{min}}$
expected	-3.80	-1.11	$(U_{min} + U_{max})/2 - h_{k_{min}}$
worst	-3.07	-1.02	$U_{max} - h_{k_{min}}$

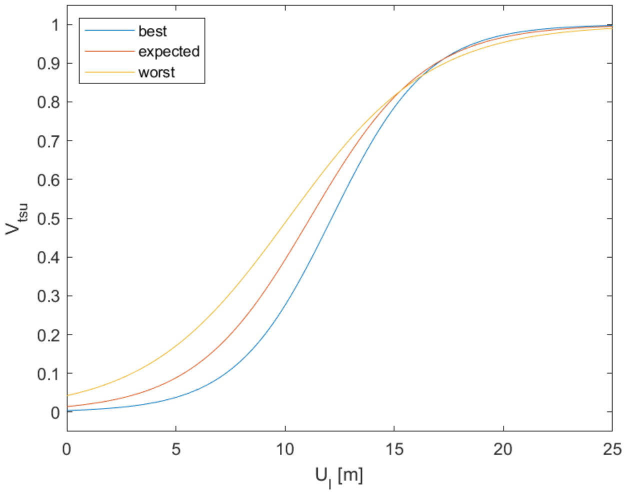

Figure 3.5: Best, worst, and expected case tsunami vulnerability models.

The tsunami vulnerability model also has the same terminology issues as the previous models. However, the intersections happen at the end stage of the domain instead of the beginning. The first intersection occurs between the worst and expected case scenario for $U \approx 15.3\ m$, after this point the model loses its logic terminology. The model can still be used for run-up waves bigger than $15.3\ m$ bearing in mind the existence of this incoherence.

Chapter 4

Results and Discussion

In this chapter, the analytical models presented in Chapters 2 and 3 are implemented and discussed. Three independent asteroid impacts were simulated for a single impact angle of 45 degrees, the Apophis and Medium Asteroid mentioned in Chapter 1, as well as a new asteroid with a diameter size of 5 kilometres. The Apophis asteroid was chosen due to its fame among the scientific community. The Medium Asteroid was selected, and its properties defined, to attempt to represent the medium risk all the NEOs pose to Earth. The 5km Impactor was added to verify the possible maximum extent of the impact effects, even though such a large-scale impact only happens approximately once every twenty million years. This chapter is then divided in 3 sections, one per impact, and further subdivided per impact effect and vulnerability.

4.1 Apophis

For the Apophis collision scenario simulation, the physical and initial impact properties are presented in Table 4.1. All the values were obtained through the respective references apart from the impact angle which was assumed and the $v_{i_{seafloor}}$ obtained via equation 2.6. The impact velocity at the sea floor is three orders of magnitude lower than the surface impact velocity. This water layer velocity attenuation results in a six-order magnitude decrease in the impact energy.

Table 4.1: Apophis physical and impact properties [8][12]

	$L\ [m]$	$\theta\ [°]$	$\rho_i\ [kg/m^3]$	$v_i\ [m/s]$	$E\ [J]$
Surface	370	45	3200	12620	6.758×10^{18}
Sea floor				5.630	1.345×10^{12}

4.1.1 Crater Dimensions

In Table 4.2 are presented the dimensions of the Apophis-induced craters either on the water surface or on the ocean floor. The values were obtained via equations 2.11 through 2.20. Both final craters are simple, its theoretical visual representation can be seen in Figures 4.1 and 4.2.

Table 4.2: Apophis impact craters dimensions

	$D_{tc}\ [m]$	$d_{tc}\ [m]$	$V_{tc}\ [m^3]$	Type	$D_{fr}\ [m]$	$d_{fr}\ [m]$	$h_{fr}\ [m]$	$t_{br}\ [m]$
Surface	6960	2460	4.69×10^{10}	Simple	8710	1850	250	860
Sea floor	146	51.8	4.36×10^{5}	Simple	183	39.0	18.1	5.25

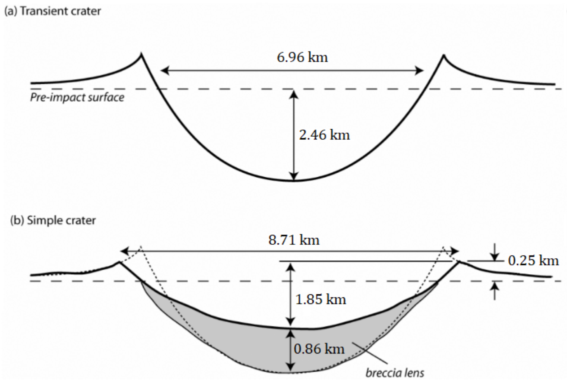

Figure 4.1: Apophis' crater dimensions for the surface transient crater (a) and simple final crater (b).

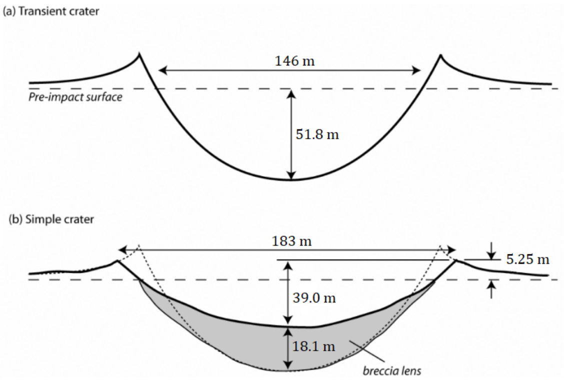

Figure 4.2: Apophis' crater dimensions for the sea floor transient crater (a) and simple final crater (b).

4.1.2 Seismic Shaking

The seismic shaking caused by the Apophis asteroid impact had an absolute magnitude of 2.3 on the Ritcher scale. The absolute magnitude M is a direct function of the impact energy E, equation 2.21. The impact velocity was reduced four orders of magnitude due to the presence of the water layer, which significantly decreased the impact energy and consequentially the seismic shaking magnitude. The absolute magnitude M is the maximum epicentral magnitude value whilst the effective magnitude M_{eff}, obtained with equation 2.22, is the magnitude value attenuated by the distance D to the epicentre, in this case the impact site. In Table 4.3 both the distance D and the effective magnitude M_{eff} of the seismic shaking produced by the impact are listed for the Portuguese district capitals. Despite the district capitals being represented in the table, the locations only correspond to the municipality in question and not the entire district. The effective magnitude M_{eff} for all computed locations

Table 4.3: Apophis-induced seismic shaking effective magnitude for district capitals' municipalities.

Municipality	$D\ [km]$	M_{eff}
Aveiro	715.2	−2.7
Beja	807.1	−2.6
Braga	751.6	−2.7
Bragança	892.5	−2.7
Castelo Branco	809.2	−2.6
Coimbra	730.5	−2.7
Évora	789.7	−2.7
Faro	837.9	−2.6
Funchal	776.6	−2.6
Guarda	830.1	−2.7
Leiria	697.2	−2.3
Lisboa	681.3	−2.2
Ponta Delgada	784.5	−2.6
Portalegre	818.0	−2.7
Porto	726.5	−2.6
Santarém	711.4	−2.6
Setúbal	705.3	−2.6
Viana do Castelo	722.5	−2.6
Vila Real	800.9	−2.6
Viseu	777.1	−2.6

as a function of the impact site distance D is graphically represented in Figure 4.3. As previously mentioned, the nature of the seismic shaking model allows for negative values which merely means that the effect does not reach, nor it is experienced in that location.

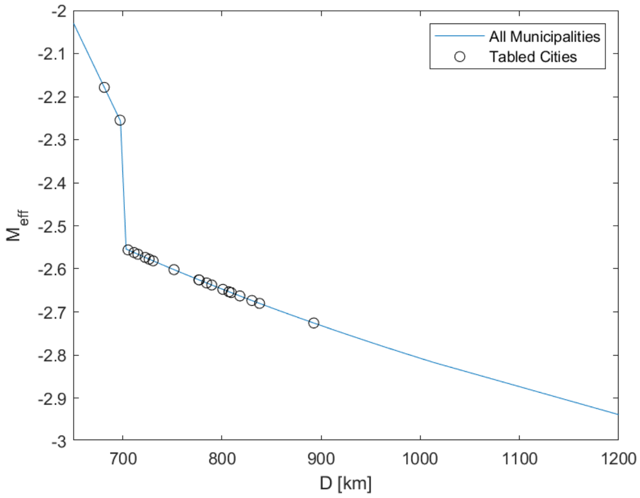

Figure 4.3: Apophis effective magnitude as a function of the municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.1.1. The markers represent the values for the district capitals.

4.1.3 Air blast

The overpressure p_D produced at the surface due to the Apophis impact is tabulated, along with the yield-scaled distance D_1 and the distance to the impact site D, in Table 4.4.

Table 4.4: Distance, Yield-scaled distance and the respective overpressure per district capital for the Apophis impact case

Municipality	$D\ [km]$	$D_1\ [km\ kt^{-1/3}]$	$P_D\ [Pa]$
Aveiro	715.2	6.10	943
Beja	807.1	6.88	829
Braga	751.6	6.41	894
Bragança	892.5	7.61	745
Castelo Branco	809.2	6.90	827
Coimbra	730.5	6.23	922
Évora	789.7	6.73	849
Faro	837.9	7.14	797
Funchal	776.6	6.62	864
Guarda	830.1	7.08	805
Leiria	697.2	5.94	969
Lisboa	681.3	5.81	993
Ponta Delgada	784.5	6.69	854
Portalegre	818.0	6.97	817
Porto	726.5	6.19	927
Santarém	711.4	6.06	949
Setúbal	705.3	6.01	957
Viana do Castelo	722.5	6.16	933
Vila Real	800.9	6.83	836
Viseu	777.1	6.62	863

The overpressure has a direct relation to the distance D_1 through equation 2.25. The yield-scaled distance D_1 is the distance to a $1Mt$ explosion that experiences the same overpressure effects as the distance D to the impact energy E, equation 2.24. In Figure 4.4 the overpressure for all municipalities can be seen. All the data used for this plot can be seen entirely in Table D.1.1. The overpressure attenuation with the distance is evident. As pressure values are in the high hundreds/low thousands, which according to Table A.3.1 would only potentially shatter windows. Logically, the casualties associated with this affect will be null or negligible.

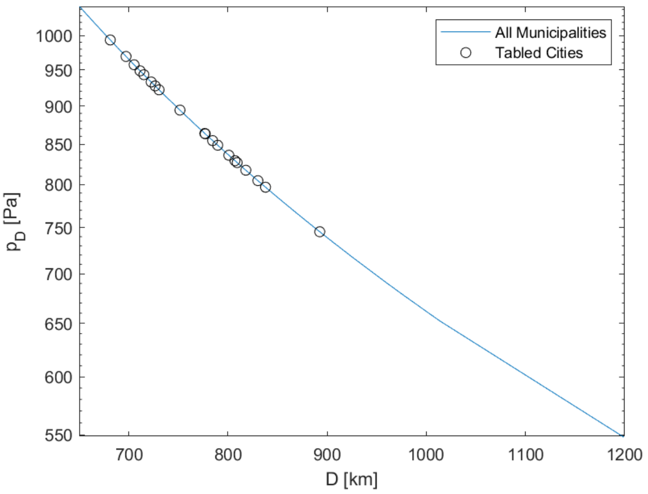

Figure 4.4: Apophis overpressure as a function of the municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.1.1. The markers represent the values for the district capitals.

4.1.4 Thermal Radiation

The first assessment in the thermal radiation study is the fireball dimension produced at impact. Any other energy transfer method will be dismissed. The radius of the fireball produced by the Apophis impact, obtained via equation 2.27, was $R_f = 3.781 \times 10^3\ m$, which falls short of directly influencing any location. This is inferred by assessing the ratio h/R_f, h is the maximum fireball height below the horizon which varies with the distance D, equation 2.30, and R_f is naturally the fireball radius. If this ratio is greater than one it means the fireball is entirely below the horizon and the location in question is shielded from direct radiation.

The last value that needs to be estimated before the thermal radiation, is the fraction of visible fireball above the horizon f. This value ranges from 0 to 1 and is intrinsically related to the maximum fireball height below the horizon h. For the first value to be 0 the second one must be greater than one, meaning the fireball is below the horizon and the fraction of said fireball visible is zero. On the other hand, if the first value is 1, the second one is mandatory to be less than 1. In this case, Earth's curvature offers no protection against the direct effects of the thermal radiation.

The assessment is complete with equation 2.28, however one last thing must be defined, the luminous efficiency η_{lum}. This value is defined as the fraction of kinetic energy that is converted into thermal radiation. It ranges from 10^{-4} to 10^{-2} and originates the upper ϕ^+ and lower ϕ^- limits for the thermal radiation experienced in any given municipality.

In Table 4.5 we can see the ratio of the maximum fireball height below the horizon and the radius of the fireball h/R_f, the fraction of the fireball above the horizon f and the high and low thermal radiation bounds ϕ, for the district capitals. As the values of h/R_f surpass the unity, the fireball is entirely below the horizon and the locations are shielded from direct exposure to the thermal radiation by the Earth's curvature.

Table 4.5: Fraction of visible fireball above the horizon and thermal radiation generated by the Apophis' collision

Municipality	h/R_f	f	ϕ^+	ϕ^-
Aveiro	10.6	0	0	0
Beja	13.5	0	0	0
Braga	11.7	0	0	0
Bragança	16.5	0	0	0
Castelo Branco	13.6	0	0	0
Coimbra	11.1	0	0	0
Évora	12.9	0	0	0
Faro	14.5	0	0	0
Funchal	12.5	0	0	0
Guarda	14.3	0	0	0
Leiria	10.1	0	0	0
Lisboa	9.62	0	0	0
Ponta Delgada	12.8	0	0	0
Portalegre	13.9	0	0	0
Porto	10.9	0	0	0
Santarém	10.5	0	0	0
Setúbal	10.3	0	0	0
Viana do Castelo	10.8	0	0	0
Vila Real	13.3	0	0	0
Viseu	12.5	0	0	0

4.1.5 Ejecta

Estimating the ejected material from the Apophis-induced crater is a simpler task. The relevant values can be obtained through direct relations. The mean ejecta fragment diameter L_e with equation 2.31 and the ejecta blanket thickness t_e with equation 2.32. The value used in the vulnerability assessment is the ejecta blanket thickness t_e and to have an impact on population it should be in the centimetre range, according to Figure 3.4. In Table 4.6 both variables are shown alongside the distance to the impact site D, for the district capitals. Even though the locations are referred as district capitals they only represent the municipality and not the entire district. In Table D.1.1 and visually in Figures 4.5 and 4.6 these values for the complete studied municipalities can be found.

The ejected material from the Apophis collision site does not present a significant size, either the mean diameter of ejecta fragments or the ejecta blanket deposition. The former is in the range of micrometres and the latter in picometres, these dimensions are purely mathematical

Table 4.6: Mean ejecta fragment diameter and ejecta blanket thickness resultant from the Apophis asteroid collision with the ocean floor.

Municipality	D $[km]$	L_e $[\mu m]$	t_e $[pm]$
Aveiro	715.2	4.05	7.81
Beja	807.1	4.89	9.67
Braga	751.6	3.10	5.78
Bragança	892.5	4.02	7.75
Castelo Branco	809.2	5.27	10.5
Coimbra	730.5	4.03	7.77
Évora	789.7	3.67	6.98
Faro	837.9	4.48	8.77
Funchal	776.6	4.36	8.50
Guarda	830.1	3.76	7.18
Leiria	697.2	5.97	12.1
Lisboa	681.3	6.34	13.0
Ponta Delgada	784.5	5.58	11.2
Portalegre	818.0	3.91	7.50
Porto	726.5	5.35	10.7
Santarém	711.4	5.66	11.4
Setúbal	705.3	5.79	11.7
Viana do Castelo	722.5	5.43	10.9
Vila Real	800.9	4.13	7.99
Viseu	777.1	4.48	8.75

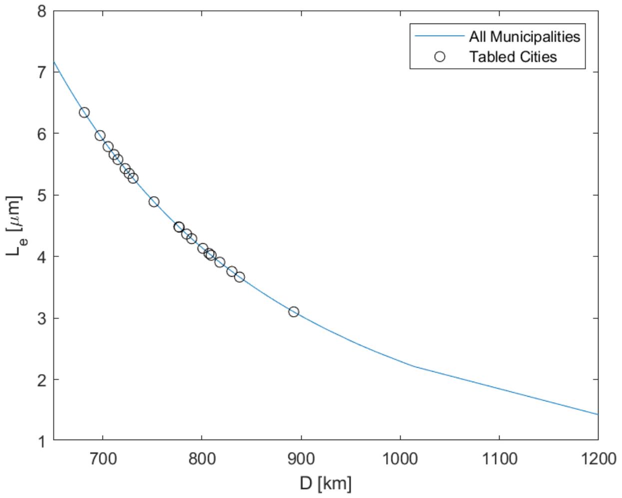

Figure 4.5: Apophis mean ejecta fragment diameter as a function of the municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.1.1. The markers represent the values for the district capitals.

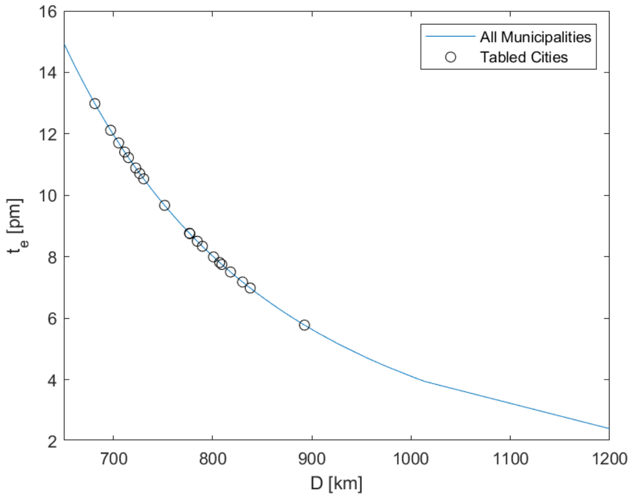

Figure 4.6: Apophis ejecta blanket thickness as a function of the municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.1.1. The markers represent the values for the district capitals.

and do not add any physical value to the simulation. Despite the large order difference both are too small to cause any concerning damage to the populations. As such, the vulnerability resulting from these values will most likely be zero or close enough not to cause any casualties.

4.1.6 Tsunami

For a deep-water impact, the tsunami wave analysis consists of three wave amplitude decay methods. Two different rim-wave amplitude methods to be compared to each other and one collapse wave amplitude decay method. Collins and Melosh in [16] stated that both rim-waves and collapse waves are formed. Wünnemann *et al.* in [17] added by saying that for a deep-water impact the collapse wave would be the greater hazard and the rim-wave could be disregarded. For each amplitude, the minimum and maximum run-up wave was computed as detailed in Section 2.8.3, where the municipalities minimum and maximum altitude needed was obtained via PORDATA, a contemporary Portugal geography database [29]. The D_{shore} values were obtained via the EDMOnet grid which presents a detailed bathymetry profile of the European seas [30]. In Tables 4.7, 4.8 and 4.9 the amplitude at the deep-shallow water threshold along with the correspondent minimum and maximum run-up are presented. The three different tables correspond to the three different wave amplitude decay methods used. In Table 4.7 is depicted the first rim wave method presented through equation 2.37. The amplitude values do not entail any disparities among themselves, it is when the run-up is assessed that the values start to diverge completely. The main disparity in the results at first glance is the run-up values for the Azores and Madeira islands. The capitals of the islands present the highest run-up values, this can be explained by the islands' volcanic nature and the diminutive continental shelf that protects the coast in mainland Portugal. In Table 4.8, where the second rim-wave amplitude method is represented, the same conclusion can be made either to the amplitude values or the run-up values. All the values are slightly smaller than the first method, but the order of magnitude is still maintained which

Table 4.7: Distance to the shore from the $800\ m$ depth point, wave amplitude at this point and run-up heights due to the Apophis impact, for the rim-wave method depicted by Rumpf

Municipality	$D\ [km]$	$D_{shore}\ [km]$	$A_{800}\ [m]$	$U_{min}\ [m]$	$U_{max}\ [m]$
Aveiro	715.2	127	5.104	6.033	6.621
Beja	807.1	70	4.992	2.423	3.183
Braga	751.6	220	4.981	4.374	7.301
Bragança	892.5	191	5.048	1.918	3.902
Castelo Branco	809.2	115	5.491	1.886	4.151
Coimbra	730.5	199	5.516	2.758	4.431
Évora	789.7	49	5.333	2.393	3.126
Faro	837.9	3.1	4.304	5.653	8.550
Funchal	776.6	14	4.389	90.23	295.3
Guarda	830.1	184	5.254	2.580	4.339
Leiria	697.2	50	5.246	6.116	9.251
Lisboa	681.3	30	5.212	10.16	13.06
Ponta Delgada	784.5	50	4.406	20.02	41.87
Portalegre	818.0	188	5.389	2.164	3.765
Porto	726.5	56	5.063	5.365	6.418
Santarém	711.4	130	5.840	2.491	4.123
Setúbal	705.3	29	5.020	10.32	16.78
Viana do Castelo	722.5	35	4.938	8.478	17.20
Vila Real	800.9	127	5.038	2.729	6.342
Viseu	777.1	121	5.175	3.138	5.331

Table 4.8: Distance to the shore from the $800\ m$ depth point, wave amplitude at this point and run-up heights due to the Apophis impact, for rim-wave method depicted by Collins

Municipality	$D\ [km]$	$D_{shore}\ [km]$	$A_{800}\ [m]$	$U_{min}\ [m]$	$U_{max}\ [m]$
Aveiro	715.2	127	3.878	5.259	5.772
Beja	807.1	70	3.793	2.112	2.775
Braga	751.6	220	3.785	3.813	6.364
Bragança	892.5	191	3.836	1.672	3.401
Castelo Branco	809.2	115	4.173	1.644	3.618
Coimbra	730.5	199	4.192	2.404	3.863
Évora	789.7	49	4.052	2.086	2.725
Faro	837.9	3.1	3.270	4.928	7.453
Funchal	776.6	14	3.335	78.66	257.4
Guarda	830.1	184	3.993	2.249	3.783
Leiria	697.2	50	3.986	5.332	8.064
Lisboa	681.3	30	3.961	8.858	11.38
Ponta Delgada	784.5	50	3.348	17.45	36.50
Portalegre	818.0	188	4.095	1.886	3.282
Porto	726.5	56	3.848	4.677	5.595
Santarém	711.4	130	4.438	2.172	3.594
Setúbal	705.3	29	3.815	8.993	14.62
Viana do Castelo	722.5	35	3.752	7.390	14.99
Vila Real	800.9	127	3.828	2.379	5.529
Viseu	777.1	121	3.932	2.735	4.647

by comparison confirms the validity of both methods. Figure 4.7 compares visually the two methods used for the rim-wave amplitude computation. This representation consolidates the similarities between both methods.

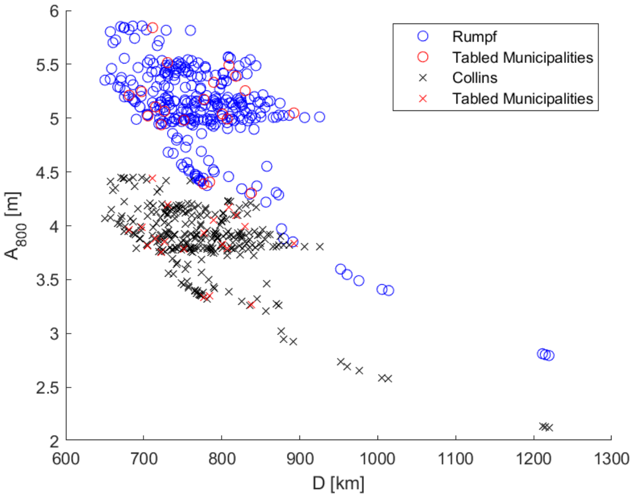

Figure 4.7: Apophis-resultant rim wave amplitude at the 800 m depth point as a function of the municipalities' distance. The different markers' colour and shape represent all municipalities for each method displayed in full in Table D.1.2. The red markers represent the values for the district capitals.

In Figures 4.8 and 4.9 lies a side-by-side comparison of the minimum and maximum run-up generated by the different amplitude methods. The results are plotted in a gridded semi-logarithmic scale for easier comparison. The run-up results are remarkably close, as there is only a slight variation in each individual run-up value. It is worth reiterating that all these run-up values are in relation to the sea level and to assess the local run-up the location altitude must be taken into consideration.

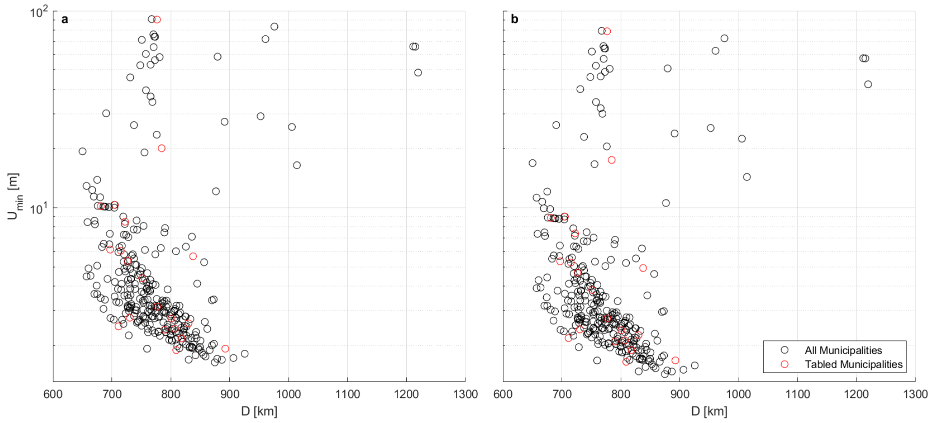

Figure 4.8: Apophis-resultant minimum run up wave, for Rumpf's amplitude method (a) and Collins' (b), at the coast as a function of the municipalities' distance. The complete data is displayed in Table D.1.2. The red markers represent the values for the district capitals.

The last wave amplitude decay method simulated was the one represented in equation 2.41 which tries to emulate the wave amplitude attenuation with the distance. These amplitude values are displayed in Table 4.9 the relation between the amplitude and run-up values is

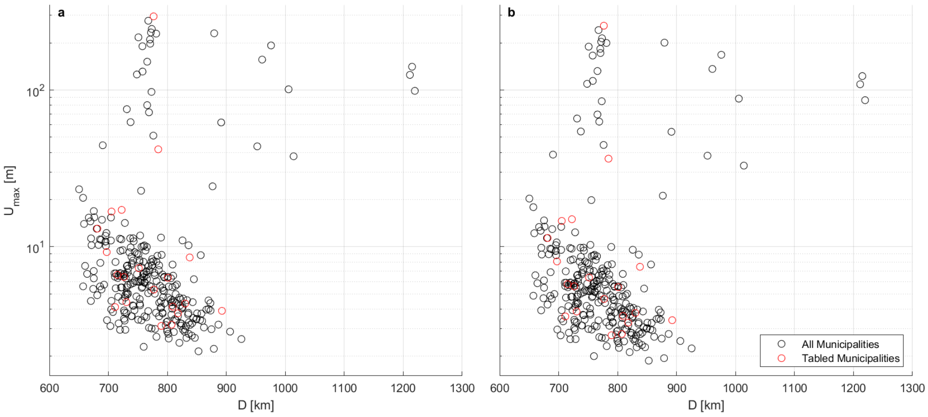

Figure 4.9: Apophis-resultant maximum run up wave, for Rumpf's amplitude method (a) and Collins' (b), at the coast as a function of the municipalities' distance. The complete data is displayed in Table D.1.2. The red markers represent the values for the district capitals.

similar to the previous discussed models. However, for the collapse wave in the Apophis' case the order of magnitude of both the amplitude and run-up are lower than the rim-wave estimations.

In Figure 4.10 is depicted each collapse wave amplitude at the $800\ m$ depth point. The main difference from the rim-wave is the amplitude magnitude. The collapse wave amplitude is in the millimetre range whilst the rim-wave amplitude was in the metre range. The correspondent minimum and maximum run-up are represented in Figure 4.11. Most of the values are inferior to one metre and a low vulnerability is to be expected.

Table 4.9: Distance to the shore from the $800\ m$ depth point, wave amplitude at this point and run-up heights due to the Apophis impact, for the collapse wave

Municipality	$D\ [km]$	$D_{shore}\ [km]$	$A_{800}\ [mm]$	$U_{min}\ [cm]$	$U_{max}\ [cm]$
Aveiro	715.2	127	5.021	18.92	20.77
Beja	807.1	70	4.717	7.446	9.784
Braga	751.6	220	4.687	13.42	22.40
Bragança	892.5	191	4.867	5.955	12.12
Castelo Branco	809.2	115	6.174	6.324	13.92
Coimbra	730.5	199	6.252	9.284	14.92
Évora	789.7	49	5.683	7.812	10.21
Faro	837.9	3.1	3.101	15.18	22.95
Funchal	776.6	14	3.278	246.6	807.0
Guarda	830.1	184	5.450	8.311	13.98
Leiria	697.2	50	5.425	19.67	29.75
Lisboa	681.3	30	5.328	32.49	41.75
Ponta Delgada	784.5	50	3.315	54.91	114.8
Portalegre	818.0	188	5.854	7.132	12.41
Porto	726.5	56	4.909	16.71	19.98
Santarém	711.4	130	7.345	8.836	14.62
Setúbal	705.3	29	4.791	31.87	51.83
Viana do Castelo	722.5	35	4.574	25.80	52.34
Vila Real	800.9	127	4.840	8.458	19.66
Viseu	777.1	121	5.220	9.966	16.93

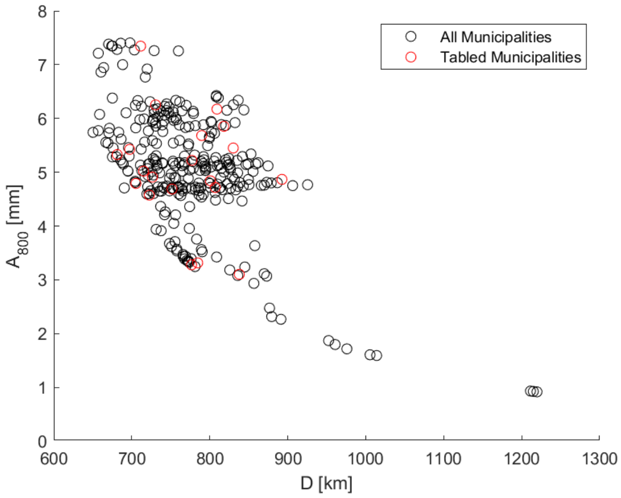

Figure 4.10: Apophis-resultant collapse wave amplitude at the 800 m depth point as a function of the municipalities' distance. The complete data is displayed in Table D.2.2. The red markers represent the values for the district capitals.

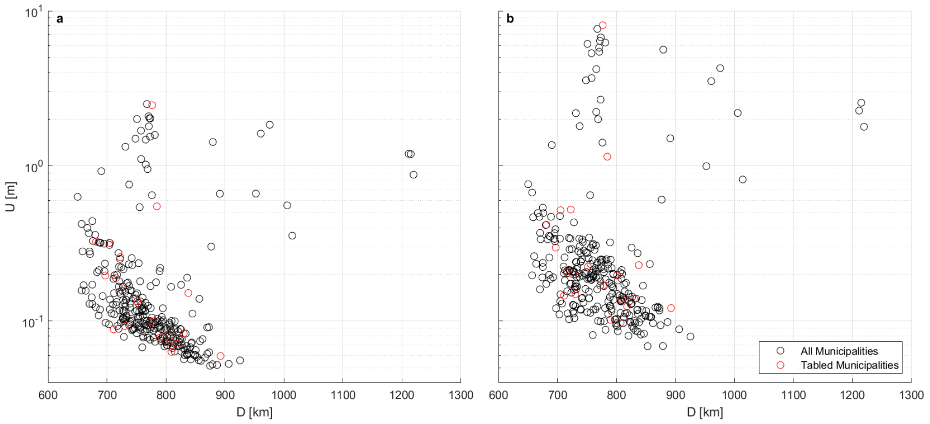

Figure 4.11: Apophis-resultant minimum (a) and maximum (b) collapse wave run up at the coast as a function of the municipalities' distance. The complete data is displayed in Table D.2.2. The red markers represent the values for the district capitals.

From only the impact effect assessment, excluding the vulnerabilities and casualties associated, the Apophis oceanic impact seems to contradict what was stated by Wünnemann *et al.* in [17]. The author claimed that, for deep-water impacts the predominant long-range wave produced was the collapse wave. The author added that rim-waves would be generated for any water impact but would decay almost immediately, distance-wise. In the present work, the rim-wave amplitude at any given location is 3 orders of magnitude larger than the collapse wave amplitude. It seems that for deep-water impacts the rim-wave formation cannot be discarded when assessing the impact hazard on a given location.

4.1.7 Global Effects

The Apophis impact changes the duration of the day on Earth by about 27 picoseconds, which is such a small submultiple that cannot even be slightly perceived by the population. The qualitative change in orbit, rotation period, tilt of axis and Earth's mass loss can be seen in Table 4.10. As the Apophis asteroid is relatively small diameter-wise and impacts Earth with an also relatively small velocity, its global implications are negligible.

Table 4.10: Global implications of the Apophis impact event

Ratio	**Value**	**Qualitative global change**
$M_i/M_{♁}$	6.4×10^{-15}	No noticeable change in orbit.
$\Gamma_i/\Gamma_{♁}$	8.2×10^{-13}	No noticeable change in rotation period and tilt of axis.
$V_{tc}/V_{♁}$	4.0×10^{-16}	Earth is not strongly disturbed and loses negligible mass.

4.1.8 Vulnerability

In this subsection are displayed the individual vulnerabilities and respective casualties for each Apophis' impact effect. Is worth reiterating that the vulnerabilities and casualties presented in this section are independent of one another. Thus, the total casualties from the Apophis impact is not the sum of the individual effects' casualties.

4.1.8.1 Seismic Shaking

As already shown in Table 4.3, the municipalities effective magnitude due to the Apophis impact is negative, which is purely a mathematical result and translates to a non-existence seismic shaking activity in any location. As there is no activity, the vulnerabilities are zero and so are the casualties.

4.1.8.2 Air blast

The overpressure vulnerabilities are divided in three different case scenarios: best, expected, and worst. For each scenario, a vulnerability V_p and subsequent casualties C_p was computed. As stated in Section 4.1.3, the air blast causalities are close to zero and borderline negligible. The vulnerabilities and casualties are depicted in Table 4.11 for the district capitals and visually in Figure 4.12 for all studied municipalities. Is important to reiterate that tabled locations, despite being the district capitals only represent the municipality in question and not the whole district. The vulnerability values for each case scenario are stagnant despite the location varying a significant number of kilometres from each other. As this stillness is present, the casualties' difference from location is mostly due to the population density discrepancy. The results also show the lost meaning of the terminology used to denote the case scenarios first referenced in Section 3.2. The best-case scenario presents a higher vulnerability and more casualties than the expected-one, which is contradictory.

Table 4.11: Apophis asteroid overpressure vulnerability and respective causalities

		best		expected		worst	
Municipality	$D\ [km]$	$V_p \times 10^5$	C_p	$V_p \times 10^5$	C_p	$V_p \times 10^5$	C_p
Aveiro	715.2	3.39	2	2.35	1	4.46	3
Beja	807.1	3.39	1	2.35	0	4.45	1
Braga	751.6	3.39	6	2.35	4	4.45	8
Bragança	892.5	3.38	1	2.34	0	4.44	1
Castelo Branco	809.2	3.39	1	2.35	1	4.45	2
Coimbra	730.5	3.39	4	2.35	3	4.46	5
Évora	789.7	3.39	1	2.35	1	4.45	2
Faro	837.9	3.39	2	2.34	1	4.44	2
Funchal	776.6	3.39	3	2.35	2	4.45	4
Guarda	830.1	3.39	1	2.34	0	4.44	1
Leiria	697.2	3.40	4	2.35	2	4.46	5
Lisboa	681.3	3.40	17	2.36	11	4.47	22
Ponta Delgada	784.5	3.39	2	2.35	1	4.45	3
Portalegre	818.0	3.39	0	2.35	0	4.44	0
Porto	726.5	3.39	7	2.35	5	4.46	9
Santarém	711.4	3.40	1	2.35	1	4.46	2
Setúbal	705.3	3.40	3	2.35	2	4.46	5
Viana do Castelo	722.5	3.39	2	2.35	1	4.46	3
Vila Real	800.9	3.39	1	2.35	1	4.45	2
Viseu	777.1	3.39	3	2.35	2	4.45	4

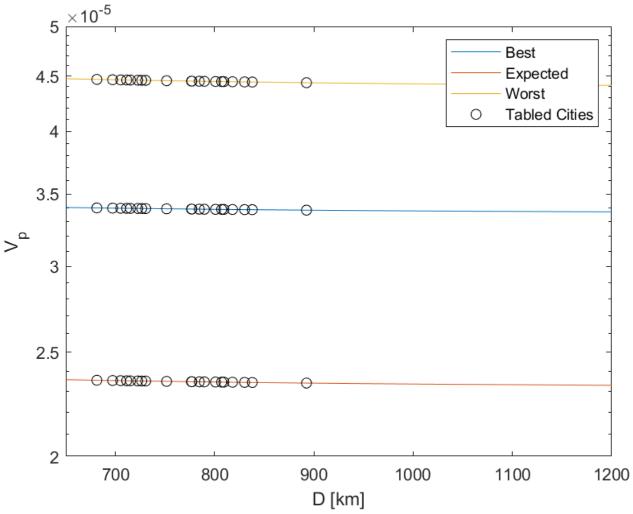

Figure 4.12: Apophis overpressure vulnerability as a function of the municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.1.3. The markers represent the values for the district capitals.

4.1.8.3 Thermal Radiation

The Apophis impact-generated fireball is not wide enough to reach any studied municipality. As the used models do not take into consideration atmospheric thermal reflection or refraction the locations are shielded from direct exposure and do not experience any radiation. The vast distance between the individual locations and the impact site safeguards the populations from thermal radiation. The non-experienced thermal radiation undoubtedly leads to a zero-vulnerability value and zero casualties.

4.1.8.4 Ejecta Blanket Deposition

The ejecta vulnerability correlates to the ejecta blanket deposit and the likelihood of a building collapse due to its load. The ejecta vulnerability model is divided into three different case scenarios. The best-case scenario assumes the buildings have a strong frame, the worst-case scenario assumes the buildings are fragile in nature and the expected case scenario is a compromise between both. The vulnerability V_e due to the deposition of material deriving from the Apophis impact's crater formation is null and so are the subsequent casualties C_e. The distance to the impact site D, the vulnerabilities and casualties for the district capitals are shown in Table 4.12. The vulnerability values are really close to zero, especially the worst-case scenario. There is also no visible difference in each location's vulnerability. As in the previous vulnerability models, the terminology disparity is present. The best-case scenario, by definition, should entail the least vulnerability value, and the worst-case scenario the higher vulnerability value. In Figure 4.13 the vulnerabilities for all municipalities can be found. The data is depicted in its entirety in Table D.1.4. Both in the figure and the tables the stillness of the vulnerabilities as a function of the distance can be observed.

Table 4.12: Apophis asteroid ejecta blanket deposition vulnerability and respective causalities

		best		expected		worst	
Municipality	D $[km]$	$V_e \times 10^8$	C_e	$V_e \times 10^{10}$	C_e	$V_e \times 10^{14}$	C_e
Aveiro	715.2	2.21	0	1.87	0	2.60	0
Beja	807.1	2.21	0	1.87	0	2.60	0
Braga	751.6	2.21	0	1.87	0	2.60	0
Bragança	892.5	2.21	0	1.87	0	2.60	0
Castelo Branco	809.2	2.21	0	1.87	0	2.60	0
Coimbra	730.5	2.21	0	1.87	0	2.60	0
Évora	789.7	2.21	0	1.87	0	2.60	0
Faro	837.9	2.21	0	1.87	0	2.60	0
Funchal	776.6	2.21	0	1.87	0	2.60	0
Guarda	830.1	2.21	0	1.87	0	2.60	0
Leiria	697.2	2.21	0	1.87	0	2.60	0
Lisboa	681.3	2.21	0	1.87	0	2.60	0
Ponta Delgada	784.5	2.21	0	1.87	0	2.60	0
Portalegre	818.0	2.21	0	1.87	0	2.60	0
Porto	726.5	2.21	0	1.87	0	2.60	0
Santarém	711.4	2.21	0	1.87	0	2.60	0
Setúbal	705.3	2.21	0	1.87	0	2.60	0
Viana do Castelo	722.5	2.21	0	1.87	0	2.60	0
Vila Real	800.9	2.21	0	1.87	0	2.60	0
Viseu	777.1	2.21	0	1.87	0	2.60	0

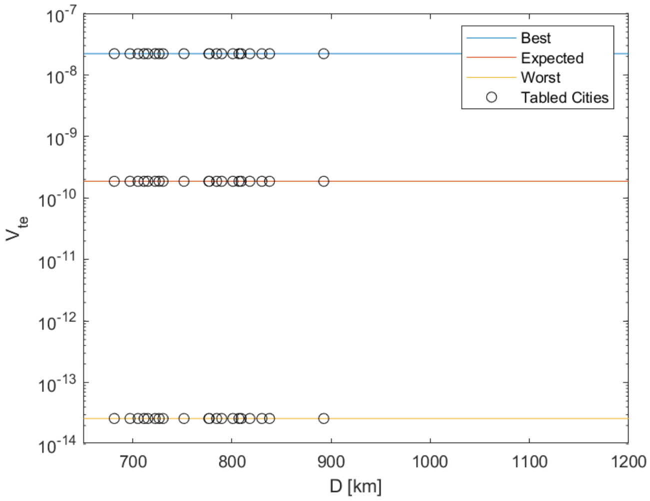

Figure 4.13: Apophis ejecta blanket deposition vulnerability as a function of the municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.1.4. The markers represent the values for the district capitals.

4.1.8.5 Tsunami

Portugal is a diverse country in terms of geographical locations. It has coastal regions prone to the tsunami hazard whilst also having mountain ranges. As such, the high altitude of most municipalities is a natural defence from the tsunami threat, which in the Apophis' case barely produces 10 meters high waves. However, Portugal's coastal regions are more exposed to this threat and exhibit vulnerabilities. In Tables 4.13 and 4.14 are displayed the vulnerabilities V_{tsu} and casualties C_{tsu} for both Rumpf and Collins rim-wave methods, respectively. When

Table 4.13: Apophis asteroid tsunami vulnerability and respective causalities, for Rumpf rim-wave method

		best		expected		worst	
Municipality	D [km]	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
Aveiro	715.2	0.059	4634	0.139	10795	0.253	19719
Beja	807.1	0.000	0	0.000	0	0.000	0
Braga	751.6	0.000	0	0.000	0	0.000	0
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.000	0	0.000	0	0.000	0
Coimbra	730.5	0.000	0	0.000	0	0.000	0
Évora	789.7	0.000	0	0.000	0	0.000	0
Faro	837.9	0.051	3082	0.177	10822	0.380	23153
Funchal	776.6	1.000	104128	1.000	104129	1.000	104129
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	0.062	7695	0.212	26480	0.432	53875
Lisboa	681.3	0.291	147515	0.544	276154	0.709	359744
Ponta Delgada	784.5	0.973	66009	0.999	67827	1.000	67859
Portalegre	818.0	0.000	0	0.000	0	0.000	0
Porto	726.5	0.045	9613	0.120	25826	0.241	51987
Santarém	711.4	0.000	0	0.000	0	0.000	0
Setúbal	705.3	0.305	35360	0.714	82621	0.884	102347
Viana do Castelo	722.5	0.161	13592	0.656	55508	0.897	75899
Vila Real	800.9	0.000	0	0.000	0	0.000	0
Viseu	777.1	0.000	0	0.000	0	0.000	0

comparing amplitude rim-wave models, based on the vulnerabilities and casualties' values, we can see that the differences are nothing but mathematical nuances and both confirm each other validity. As expected, the islands have the highest vulnerabilities among the municipalities, as the waves the model predicts are massive compared to the remaining locations.

In addition to the tabled values, in Figures 4.14 and 4.15 a visual representation of the vulnerabilities can be seen. The different case scenarios: best, expected and worst are present in the figures side-by-side with one another. The most evident conclusion in the tsunami vulnerability study is that there is no correlation between the vulnerability and the distance from the impact site. As such, by elimination, the plurality of values for a single distance D must be mainly due to the shore slope s.

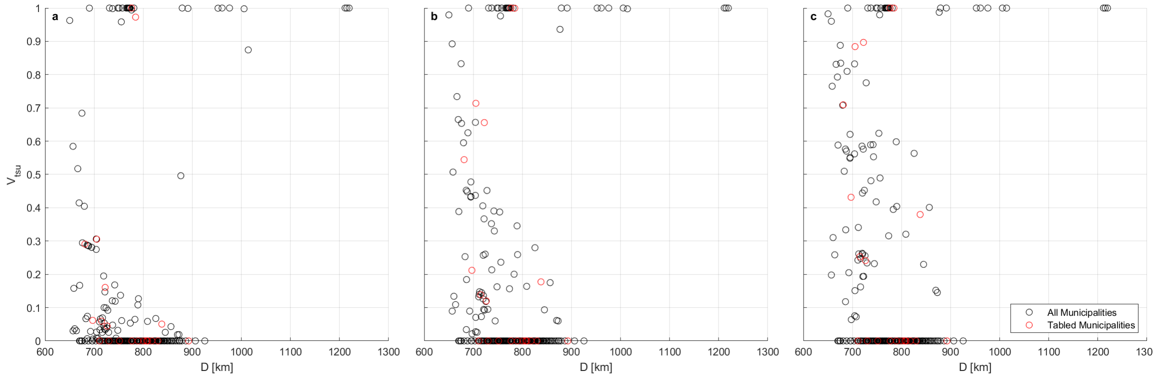

Figure 4.14: Apophis rim-wave vulnerability best (a), expected (b) and worst case-scenario (c) as a function of the municipalities' distance, for Rumpf's method. The complete data is displayed in Table D.1.5. The red markers represent the values for the district capitals.

Table 4.14: Apophis asteroid tsunami vulnerability and respective causalities, for Collins rim-wave method

		best		expected		worst	
Municipality	D $[km]$	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
Aveiro	715.2	0.043	3323	0.106	8234	0.207	16132
Beja	807.1	0.000	0	0.000	0	0.000	0
Braga	751.6	0.000	0	0.000	0	0.000	0
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.000	0	0.000	0	0.000	0
Coimbra	730.5	0.000	0	0.000	0	0.000	0
Évora	789.6	0.000	0	0.000	0	0.000	0
Faro	837.9	0.037	2251	0.132	8076	0.304	18551
Funchal	776.6	1.000	104128	1.000	104129	1.000	104129
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	0.044	5495	0.156	19504	0.345	43114
Lisboa	681.3	0.185	93928	0.404	205109	0.593	300975
Ponta Delgada	784.5	0.918	62268	0.998	67698	1.000	67842
Portalegre	818.0	0.000	0	0.000	0	0.000	0
Porto	726.5	0.033	7124	0.093	19980	0.198	42686
Santarém	711.4	0.000	0	0.000	0	0.000	0
Setúbal	705.3	0.195	22522	0.563	65184	0.798	92344
Viana do Castelo	722.5	0.105	8859	0.505	42730	0.815	69008
Vila Real	800.9	0.000	0	0.000	0	0.000	0
Viseu	777.1	0.000	0	0.000	0	0.000	0

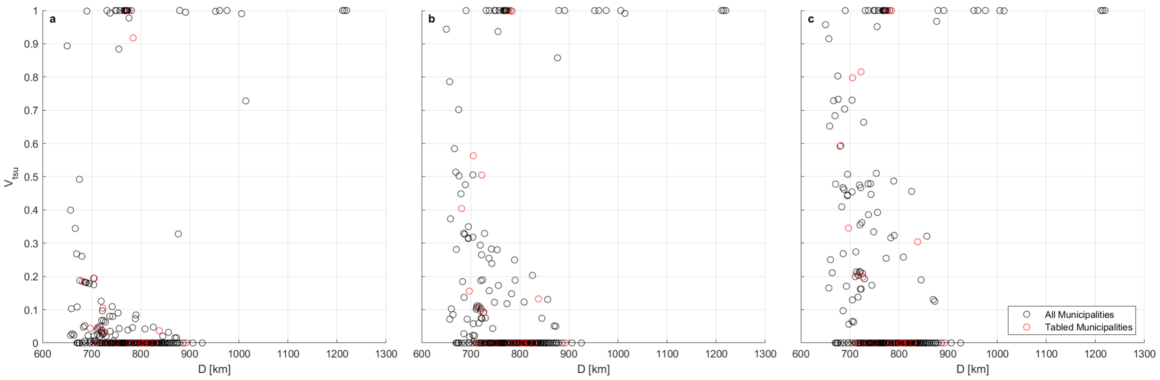

Figure 4.15: Apophis rim-wave vulnerability best (a), expected (b) and worst case-scenario (c) as a function of the municipalities' distance, for Collins' method. The complete data is displayed in Table D.1.5. The red markers represent the values for the district capitals.

The collapse wave vulnerabilities and casualties are depicted in Table 4.15 for the specified municipalities, and visually in Figure 4.16. As expected from the run-up waves comparison between rim and collapse waves, the vulnerabilities and consequently the casualties are much lower than that of the rim-wave. For the Apophis's impact scenario, the collapse wave is a minor threat in relation to the rim-wave. As the impact occurs in deep water, the results contradict the statement made by Wünnemann *et al.* that collapse waves are the main concerning wave in deep oceanic impact hazard.

Table 4.15: Apophis asteroid collapse wave vulnerability and respective causalities

		best		expected		worst	
Municipality	D [km]	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
Aveiro	715.2	0.004	347	0.015	1203	0.045	3525
Beja	807.1	0.000	0	0.000	0	0.000	0
Braga	751.6	0.000	0	0.000	0	0.000	0
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.000	0	0.000	0	0.000	0
Coimbra	730.5	0.000	0	0.000	0	0.000	0
Évora	789.6	0.000	0	0.000	0	0.000	0
Faro	837.9	0.004	267	0.015	939	0.046	2776
Funchal	776.6	0.012	1293	0.097	10114	0.346	36002
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	0.004	559	0.016	1964	0.046	5799
Lisboa	681.3	0.005	2408	0.016	8359	0.048	24402
Ponta Delgada	784.5	0.005	356	0.020	1336	0.059	4036
Portalegre	818.0	0.000	0	0.000	0	0.000	0
Porto	726.5	0.004	951	0.015	3307	0.045	9718
Santarém	711.4	0.000	0	0.000	0	0.000	0
Setúbal	705.3	0.005	548	0.017	1941	0.050	5735
Viana do Castelo	722.5	0.005	389	0.017	1405	0.050	4199
Vila Real	800.9	0.000	0	0.000	0	0.000	0
Viseu	777.1	0.000	0	0.000	0	0.000	0

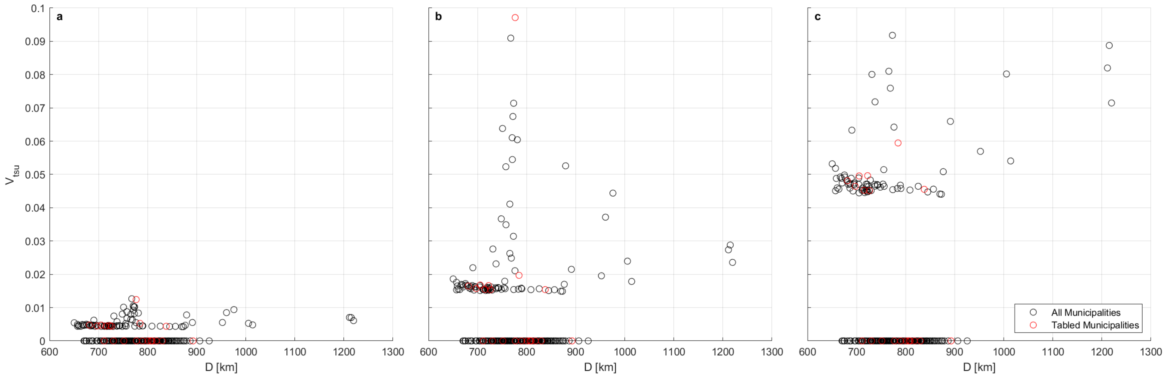

Figure 4.16: Apophis collapse wave best (a), expected (b) and worst case-scenario (c) vulnerability as a function of the municipalities' distance. The complete data is displayed in Table D.1.5. The red markers represent the values for the district capitals.

4.1.9 Timeline

In Lisbon, the only effects experienced due to the Apophis impact is the air blast and the tsunami. Figure 4.17 is a visual representation of the timeline of events. At the zero seconds mark occurs the Apophis impact and subsequent crater formation, 33 minutes after the impact a shock wave of $993\ Pa$ hits Lisbon. The tsunami waves hit the coast approximately 1 hours 49 minutes after the impact. The first wave has a run-up of $8.9\ m$. The second wave only has a run-up of $32.5\ cm$.

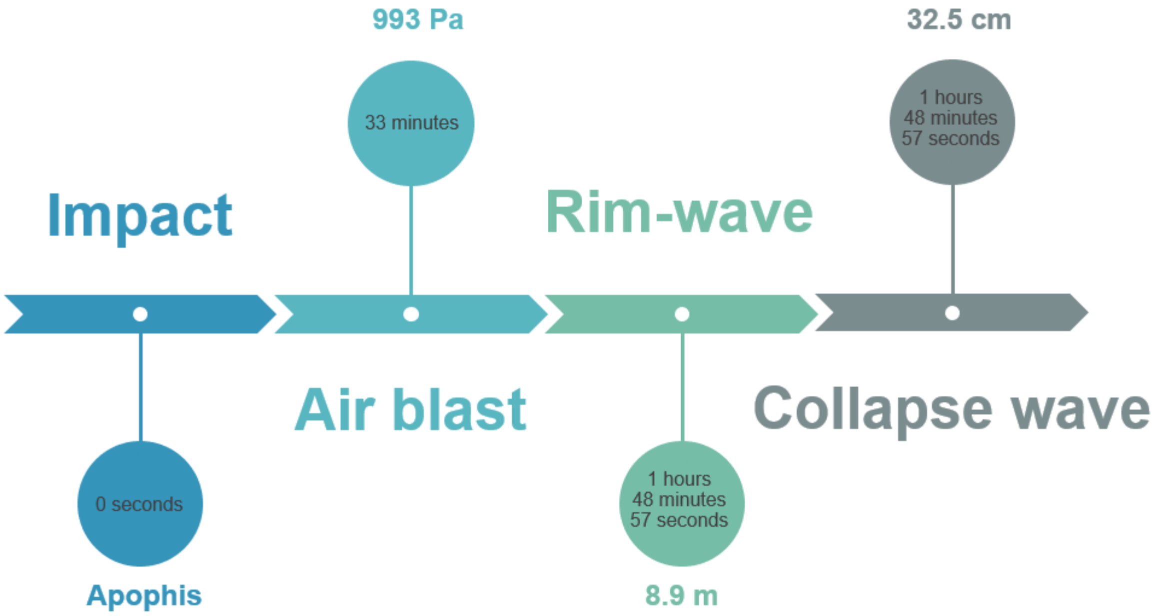

Figure 4.17: Apophis impact effects' timeline experienced in the capital of Portugal.

4.2 Medium Asteroid

As mentioned in Chapter 1, the Medium Asteroid's diameter and impact velocity consist of the medium values of nine thousand plus NEOs. The impact angle was set at $45°$ and the asteroid's density at $3100\ kg/m^3$. The density value was assigned by Rumpf *et al.* in [26] as representative value for an even larger asteroid population. In Table 4.16 all the aforementioned properties are displayed, along with the sea floor impact velocity $v_{i_{seafloor}}$ and the impact energy E, obtained with equations 2.6 and 2.10, respectively. The tremendous impact velocity attenuation due to the water layer presence is evident. The sea floor impact velocity is negligible, and it can be concluded that, for the Medium Asteroid case-scenario, the water layer completely suppresses the impact.

Table 4.16: Medium Asteroid physical and impact properties

	$L\ [m]$	$\theta\ [°]$	$\rho_i\ [kg/m^3]$	$v_i\ [m/s]$	$E\ [J]$
Surface	204	45	3100	10840	8.096×10^{17}
Sea floor				0.0058	2.302×10^{5}

4.2.1 Crater Dimensions

Both the surface and sea floor Medium Asteroid-generated craters dimension can be seen in Table 4.17 and visually in Figures 4.18 and 4.19, even though it was previously mentioned that the sea floor crater formation could be disregarded. As anticipated, the Medium Asteroid's surface crater is smaller than the one generated by the Apophis' impact. This is not only due to the Medium Asteroid's smaller diameter but also its lower impact velocity.

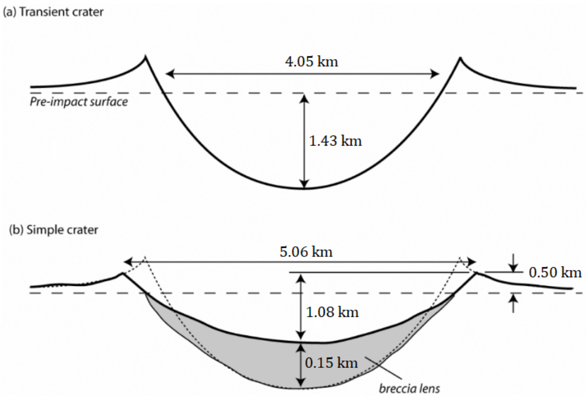

Figure 4.18: Medium Asteroid's crater dimensions for the surface transient crater (a) and simple final crater (b).

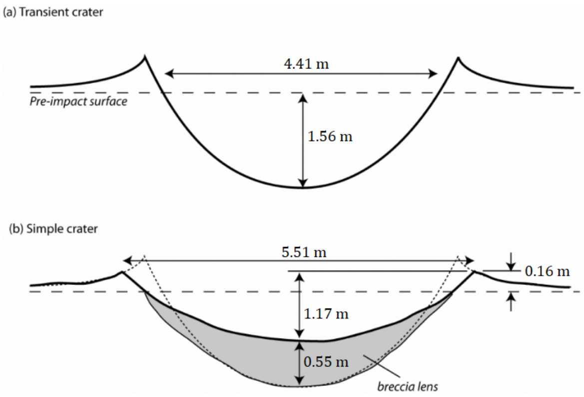

Figure 4.19: Medium Asteroid's crater dimensions for the sea floor transient crater (a) and simple final crater (b).

Table 4.17: Medium Asteroid impact craters dimensions

	$D_{tc}\ [m]$	$d_{tc}\ [m]$	$V_{tc}\ [m^3]$	Type	$D_{fr}\ [m]$	$d_{fr}\ [m]$	$h_{fr}\ [m]$	$t_{br}\ [m]$
Surface	4.05×10^{3}	1.43×10^{3}	9.23×10^{9}	Simple	5.06×10^{3}	1.08×10^{3}	1.45×10^{2}	5.00×10^{2}
Sea floor	4.41×10^{0}	1.56×10^{0}	1.19×10^{1}	Simple	5.51×10^{0}	1.17×10^{0}	1.58×10^{-1}	5.54×10^{-1}

4.2.2 Seismic Shaking

The ocean floor impact of the Medium Asteroid results in a seismic shaking of magnitude $M = -2.3$, this value besides being purely theoretical means that there is not a creation of a seismic wave. The non-existing seismic wave, due to the asteroid reaching the sea floor at such low velocity, corroborates the possibility of disregarding the ocean floor impact completely.

4.2.3 Air blast

The overpressure values arisen from the Medium Asteroid's impact-induced shock wave were obtained with equation 2.25. But first, the yield-scaled distance D_1 is needed. The distance D_1 is the distance to a $1Mt$ explosion that experiences the same overpressure effects as the distance D from impact energy E. In Table 4.18 the overpressure values are presented for the district capitals along with the distances D and D_1, obtained through equations 2.1 and 2.24. The district capitals represent only the homonymous municipality and not the entire district. The overpressure as a function of the distance to the impact site D is graphically represented in Figure 4.20 for all municipalities. The complete data is found in Table D.2.1. The smaller dimension and velocity of the Medium Asteroid will cause its impact effects to be lower than Apophis' impact effects. This is mainly due to the paramount role the impact energy has in computing the impact effects, and identically the asteroid's diameter and velocity role in the impact energy. In conclusion, a smaller diameter and velocity leads to a smaller impact energy which leads to a less significant impact effect, a smaller vulnerability, and finally fewer casualties.

Table 4.18: Yield-scaled distance and the respective overpressure per district capital for the Medium Asteroid impact case

Municipality	D $[km]$	D_1 $[km\ kt^{-1/3}]$	P_D $[Pa]$
Aveiro	715.2	12.36	450
Beja	807.1	13.95	397
Braga	751.6	12.99	427
Bragança	892.5	15.43	358
Castelo Branco	809.2	13.99	396
Coimbra	730.5	12.63	440
Évora	789.7	13.65	406
Faro	837.9	14.49	382
Funchal	776.6	13.43	413
Guarda	830.1	14.35	386
Leiria	697.2	12.05	462
Lisboa	681.3	11.78	473
Ponta Delgada	784.5	13.56	409
Portalegre	818.0	14.14	392
Porto	726.5	12.56	443
Santarém	711.4	12.30	452
Setúbal	705.3	12.19	456
Viana do Castelo	722.5	12.49	445
Vila Real	800.9	13.85	400
Viseu	777.1	13.44	413

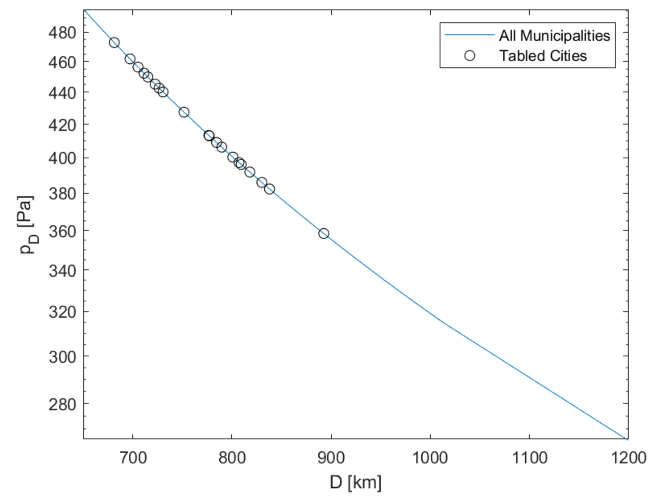

Figure 4.20: Medium Asteroid overpressure as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.2.1. The markers represent the values for the district capitals.

As expected, the air blast follows this predicament as the overpressure values equate to roughly half the Apophis' overpressure values. If, in the Apophis' case, the overpressure would barely shatter windows and produce practically zero casualties, the same can be said for the Medium Asteroid's case.

4.2.4 Thermal Radiation

From the equation 2.27 application, the radius of the fireball produced by the Medium Asteroid impact was found to be $R_f = 1.864 \times 10^3\ m$. The fireball radius is a paramount value because the fireball is the impact effect that ultimately causes thermal radiation. To determine the radiation that reaches a given municipality first two fractions need to be estimated that relate to the percentile direct exposure of any location. The first one is the ratio of the maximum fireball height below the horizon and the fireball radius h/R_f. The second one is fraction of visible fireball over the horizon f. Both are intrinsically related: if $h/R_f > 1$ then $f = 0$ and the municipality is completely shielded from direct exposure; if $0 < h/R_f < 1$ then $0 < f < 1$ meaning the location is exposed to thermal radiation but has some protection; if $h/R_f = 0$ then $f = 1$ and the location is completely exposed, making Earth's curvature irrelevant.

To complete the assessment and estimate the thermal radiation per location we need only to define the luminous efficiency. This value is the fraction of kinetic energy converted into thermal radiation. It ranges from 10^{-4} to 10^{-2} setting the upper ϕ^+ and lower ϕ^- thermal radiation limits defined in the present work. In Table 4.19 all the aforementioned variables are shown for the district capitals. The similarities between the Apophis' impact case and the one being currently exposed are evident once again. All the values surpass the unity, as such the locations are shielded from direct radiation and do not experience any thermal exposure. This is true for every location studied as can be seen in Table D.2.1. Since every location has

Table 4.19: Fraction of visible fireball above the horizon and thermal radiation generated by the Medium Asteroid's collision

Municipality	h/R_f	f	ϕ^+	ϕ^-
Aveiro	21.5	0	0	0
Beja	27.4	0	0	0
Braga	23.8	0	0	0
Bragança	33.5	0	0	0
Castelo Branco	27.5	0	0	0
Coimbra	22.4	0	0	0
Évora	26.2	0	0	0
Faro	29.5	0	0	0
Funchal	25.4	0	0	0
Guarda	29.0	0	0	0
Leiria	20.4	0	0	0
Lisboa	19.5	0	0	0
Ponta Delgada	25.9	0	0	0
Portalegre	28.1	0	0	0
Porto	22.2	0	0	0
Santarém	21.3	0	0	0
Setúbal	20.9	0	0	0
Viana do Castelo	22.0	0	0	0
Vila Real	27.0	0	0	0
Viseu	25.4	0	0	0

a zero Joule per metre thermal exposure, the vulnerabilities and casualties associated with this impact effect are undoubtedly also zero.

Table 4.20: Mean ejecta fragment diameter and ejecta blanket thickness resultant from the Medium Asteroid collision with the ocean floor

Municipality	$D\ [km]$	$L_e[nm]$	$t_e[am]$
Aveiro	715.2	151	9.23
Beja	807.1	110	6.42
Braga	751.6	133	7.95
Bragança	892.5	84.1	4.75
Castelo Branco	809.2	109	6.37
Coimbra	730.5	143	8.66
Évora	789.7	116	6.86
Faro	837.9	99.4	5.74
Funchal	776.6	122	7.21
Guarda	830.1	102	5.90
Leiria	697.2	162	9.97
Lisboa	681.3	172	10.7
Ponta Delgada	784.5	118	6.99
Portalegre	818.0	106	6.17
Porto	726.5	145	8.81
Santarém	711.4	153	9.38
Setúbal	705.3	157	9.63
Viana do Castelo	722.5	147	8.95
Vila Real	800.9	112	6.57
Viseu	777.1	121	7.20

4.2.5 Ejecta

In previous sections, the non-formation of an ocean floor crater was addressed. For exposition's sake the ejected material was computed and presented in Table 4.20 for the district capitals. The mean ejecta fragment diameter L_e and the ejecta blanket thickness t_e exhibit a metre submultiple range of nanometres and attometres. Both considerably small in comparison to the event scale being considered. Besides, the nature of the metric units is purely theoretical, a by-product of the implemented mathematical models and do not entail any physical value that could be crucial to the study. Therefore, the vulnerabilities and casualties are assuredly zero. Both the mean ejecta fragment diameter and the ejecta blanket thickness are represented graphically in Figures 4.21 and 4.22, respectively.

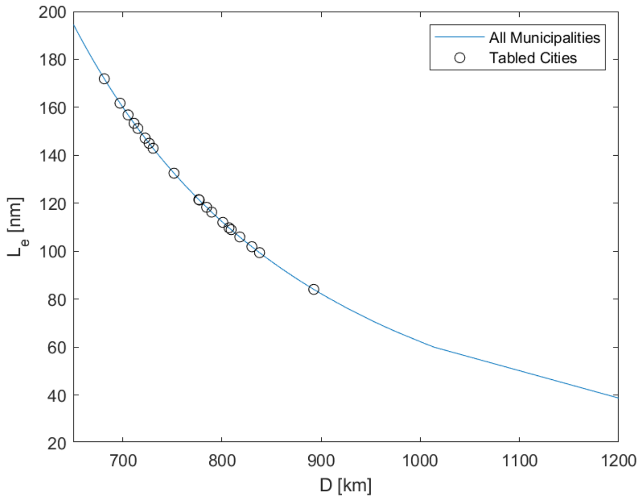

Figure 4.21: Medium Asteroid mean ejecta fragment diameter as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.2.1. The markers represent the values for the district capitals.

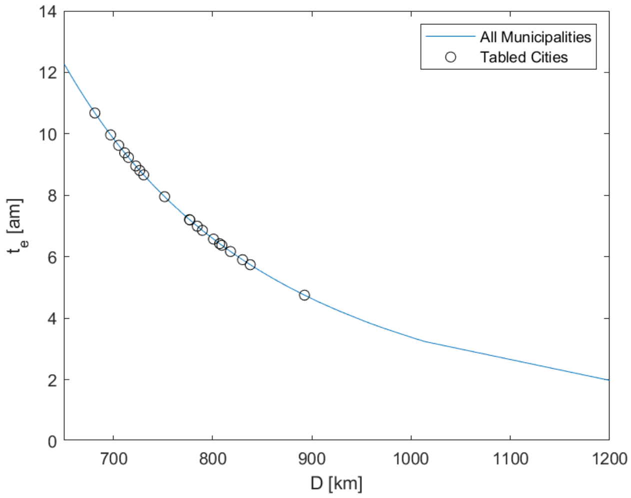

Figure 4.22: Medium Asteroid ejecta blanket thickness as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.2.1. The markers represent the values for the district capitals.

4.2.6 Tsunami

The ratio L_0/h_{sea} labels the Medium Asteroid's and the Apophis' impact as a deep-water impact. As stated by Collins and Melosh in [16] both rim-waves and collapse waves are formed. Wünnemann *et al.* in [17] adds by saying that for a deep-water impact the collapse wave would be the greater hazard and the rim-wave could be disregarded. The Medium Asteroid oceanic impact resembles the Apophis albeit the absolute values difference. This result display method is consistent, Tables 4.21, 4.22 and 4.23 withhold the amplitude values at the 800 m threshold, minimum run-up and maximum run-up values. In Table 4.21 are presented the Rumpf amplitude model-derived values. The absolute nature of the values is clearly different from the Apophis impact scenario. However, the values relative nature towards each other is similar if not equal to the Apophis case. From this observation can be concluded that the impact energy dictates the absolute values considered: amplitude and run-up, and the slope disparities between locations dictates its relative relation. In Figure 4.23 are graphed all the amplitude values for both rim-wave method. The previous point made can be seen here clearly, as this figure morphology is evidently similar to Figure 4.7.

Table 4.21: Distance to the shore from the 800 m depth point, wave amplitude at this point and run-up heights due to the Medium Asteroid impact, for the rim-wave method depicted by Rumpf

Municipality	D $[km]$	D_{shore} $[km]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
Aveiro	715.2	127	1.727	2.676	2.937
Beja	807.1	70	1.689	1.075	1.412
Braga	751.6	220	1.685	1.940	3.239
Bragança	892.5	191	1.708	0.851	1.731
Castelo Branco	809.2	115	1.858	0.837	1.841
Coimbra	730.5	199	1.866	1.223	1.966
Évora	789.7	49	1.804	1.062	1.387
Faro	837.9	3.1	1.456	2.508	3.793
Funchal	776.6	14	1.485	40.03	131.0
Guarda	830.1	184	1.778	1.145	1.925
Leiria	697.2	50	1.775	2.713	4.104
Lisboa	681.3	30	1.763	4.508	5.792
Ponta Delgada	784.5	50	1.491	8.881	18.57
Portalegre	818.0	188	1.823	0.960	1.670
Porto	726.5	56	1.713	2.380	2.847
Santarém	711.4	130	1.976	1.105	1.829
Setúbal	705.3	29	1.698	4.576	7.442
Viana do Castelo	722.5	35	1.671	3.761	7.630
Vila Real	800.9	127	1.705	1.210	2.813
Viseu	777.1	121	1.751	1.392	2.365

Figures 4.24 and 4.25 represent a side-by-side comparison between the minimum and maximum run-up generated by the different amplitude methods. The results are plotted in a gridded semi-logarithmic scale for easier parallelism. The run-up results are incredibly alike, there is only a slight variation between each individual run-up value. It is worth reiterating that all these run-up values are in relation to the sea level and to assess the local run-up the location altitude must be taken into consideration.

Table 4.22: Distance to the shore from the 800 m depth point, wave amplitude at this point and run-up heights due to the Medium Asteroid impact, for rim-wave method depicted by Collins

Municipality	D $[km]$	D_{shore} $[km]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
Aveiro	715.2	127	1.312	2.333	2.560
Beja	807.1	70	1.283	0.937	1.231
Braga	751.6	220	1.281	1.691	2.823
Bragança	892.5	191	1.298	0.742	1.509
Castelo Branco	809.2	115	1.412	0.729	1.605
Coimbra	730.5	199	1.418	1.066	1.714
Évora	789.7	49	1.371	0.925	1.209
Faro	837.9	3.1	1.106	2.186	3.306
Funchal	776.6	14	1.128	34.89	114.2
Guarda	830.1	184	1.351	0.998	1.678
Leiria	697.2	50	1.349	2.365	3.577
Lisboa	681.3	30	1.340	3.929	5.049
Ponta Delgada	784.5	50	1.133	7.742	16.19
Portalegre	818.0	188	1.385	0.837	1.456
Porto	726.5	56	1.302	2.075	2.482
Santarém	711.4	130	1.501	0.963	1.594
Setúbal	705.3	29	1.291	3.989	6.487
Viana do Castelo	722.5	35	1.270	3.278	6.651
Vila Real	800.9	127	1.295	1.055	2.452
Viseu	777.1	121	1.330	1.213	2.061

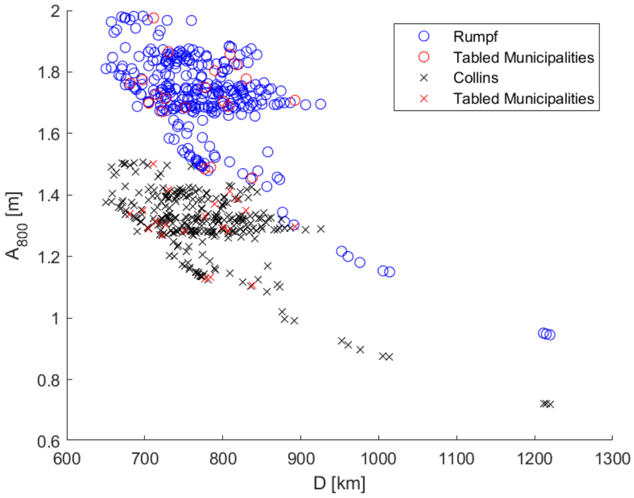

Figure 4.23: Medium Asteroid-resulting rim wave amplitude at the 800 m depth point as a function of the municipalities' distance. The different markers' colour and shape represent all municipalities for each method displayed in full in Table D.2.2. The red markers represent the values for the district capitals.

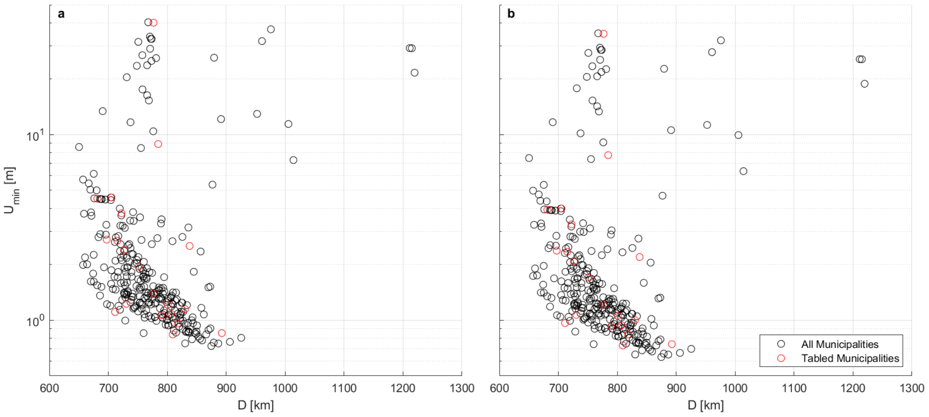

Figure 4.24: Medium Asteroid-resultant minimum run up wave, for Rumpf's amplitude method (a) and Collins' (b), at the coast as a function of the municipalities' distance. The complete data is displayed in Table D.2.2. The red markers represent the values for the district capitals.

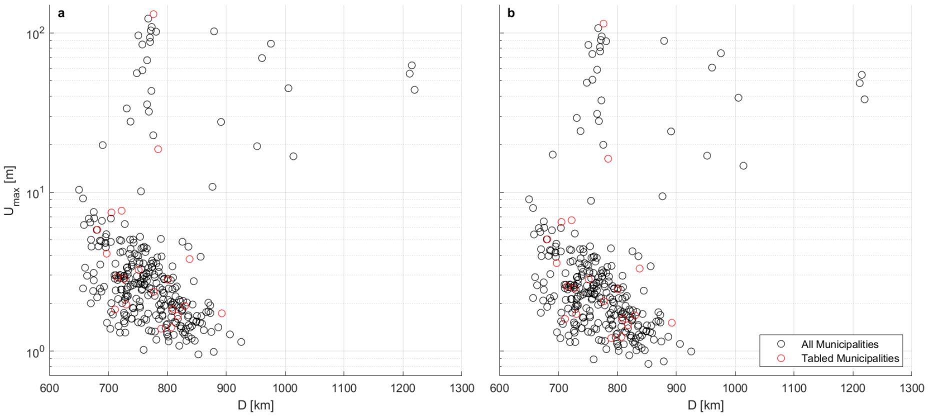

Figure 4.25: Medium Asteroid-resultant maximum run up wave, for Rumpf's amplitude method (a) and Collins' (b), at the coast as a function of the municipalities' distance. The complete data is displayed in Table D.2.2. The red markers represent the values for the district capitals.

The final wave studied in the Medium Asteroid's case was the collapse wave. By analogy with the Apophis' impact scenario this wave is expected to be less threatening to the coast as the first one. The collapse wave amplitude values and run-up are shown in Table 4.23. Here it can be seen that the wave amplitude only reaches the millimetre range and the run-up, either minimum or maximum stay within the centimetre range. From a pragmatic point of view, a wave with only a centimetre run-up would barely reach inland at all. So, a reliable conclusion would be that the collapse wave would cause no casualties. To complement the table, in Figure 4.26 there is a visual representation of the amplitudes for every municipality considered in the study. Analysing the amplitude and distance is evident a lack of patterns.

To complete the tsunami analysis in the current impact scenario, in Figure 4.27 are plotted the minimum and maximum run-up of the collapse wave side-by-side. The graphs are displayed on a semi-logarithmic scale, the run-up axis is logarithmic, and the distance axis is linear. All these run-up values correspond to the run-up heights at the sea level. To obtain the local run-up needed for the vulnerability assessment the minimum altitude of each location

Table 4.23: Distance to the shore from the 800 m depth point, wave amplitude at this point and run-up heights due to the Medium Asteroid impact, for the collapse wave

Municipality	D $[km]$	D_{shore} $[km]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Aveiro	715.2	127	0.457	4.354	4.779
Beja	807.1	70	0.429	1.712	2.249
Braga	751.6	220	0.426	3.085	5.149
Bragança	892.5	191	0.443	1.370	2.787
Castelo Branco	809.2	115	0.565	1.459	3.212
Coimbra	730.5	199	0.573	2.143	3.443
Évora	789.7	49	0.519	1.801	2.352
Faro	837.9	3.1	0.279	3.469	5.247
Funchal	776.6	14	0.295	56.42	184.6
Guarda	830.1	184	0.497	1.915	3.220
Leiria	697.2	50	0.495	4.531	6.853
Lisboa	681.3	30	0.486	7.482	9.615
Ponta Delgada	784.5	50	0.298	12.56	26.27
Portalegre	818.0	188	0.535	1.645	2.862
Porto	726.5	56	0.447	3.843	4.597
Santarém	711.4	130	0.676	2.044	3.383
Setúbal	705.3	29	0.436	7.329	11.92
Viana do Castelo	722.5	35	0.415	5.930	12.03
Vila Real	800.9	127	0.440	1.945	4.521
Viseu	777.1	121	0.476	2.294	3.898

needs to be factored in.

The Medium Asteroid's tsunami assessment further establishes the validity of the statement declared at the end of the Apophis' tsunami calculation. The results here shown go against what has already been stated between tsunami waves and deep-water impacts. The results shown a clear downside of the collapse wave threat when compared to the rim-wave threat, for both oceanic impacts covered so far.

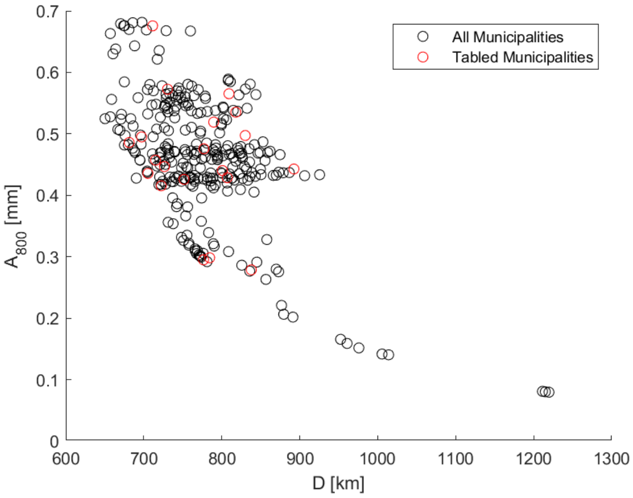

Figure 4.26: Medium Asteroid-resultant collapse wave amplitude at the 800 m depth point as a function of the municipalities' distance. The complete data is displayed in Table D.2.2. The red markers represent the values for the district capitals.

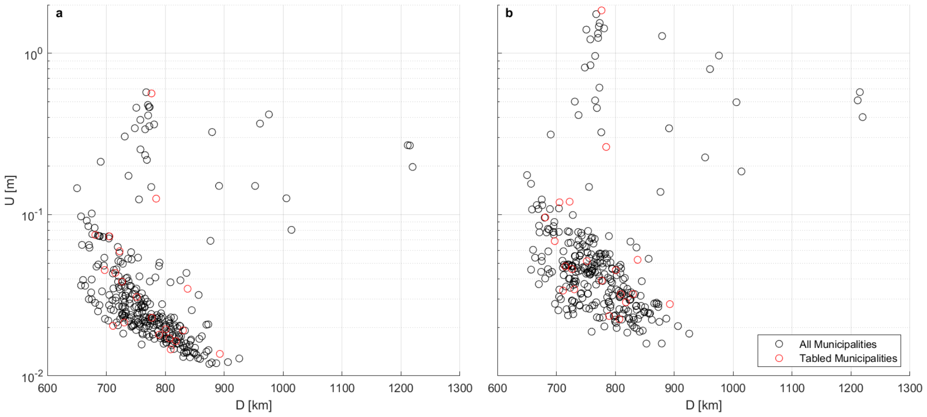

Figure 4.27: Medium Asteroid-resultant minimum (a) and maximum (b) collapse wave run up at the coast as a function of the municipalities' distance. The complete data is displayed in Table D.2.2. The red markers represent the values for the district capitals.

4.2.7 Global Effects

The Medium Asteroid's impact changes the Earth's day length by about 4.5 femtosecond which is a unit so small that has no real meaning in this study. The remaining qualitative global changes due to the Medium Asteroid's impact can be seen in Table 4.24. Once again, the analogy between the Apophis and Medium Asteroid impact can be used to infer the results. As the Medium Asteroid is in general a smaller impact threat than the Apophis, its global implication will also be negligible.

Table 4.24: Global implications of the Medium Asteroid impact event

Ratio	**Value**	**Qualitative global change**
$M_i/M_{♁}$	8.9×10^{-16}	No noticeable change in orbit.
$\Gamma_i/\Gamma_{♁}$	1.1×10^{-13}	No noticeable change in rotation period and tilt of axis.
$V_{tc}/V_{♁}$	1.1×10^{-20}	Earth is not strongly disturbed and loses negligible mass.

4.2.8 Vulnerability

In this subsection are displayed the individual vulnerabilities and respective casualties for each Medium Asteroid's impact effect. Is worth reiterating that the casualties are obtained as a simple product between the vulnerability and the population of a given location.

4.2.8.1 Seismic Shaking

The seismic shaking vulnerability results are clear, either if it is assumed a sea floor impact or not. For any case, the vulnerabilities are undoubtedly zero. If we assume an impact, the extreme low velocity with which the asteroid reaches the benthic layer ensues a purely mathematical negative value for the absolute magnitude of the seismic shaking and thus the formation of seismic waves does not occur. On the other hand, if we assume from the beginning that the water layer completely absorbs the impact, the asteroid will not reach the sea floor and thus not create a seismic shaking event.

4.2.8.2 Air blast

The overpressure vulnerability model is divided in three different case scenarios: best, expected, and worst. Each scenario entails a specific overpressure vulnerability V_p and a subsequent casualties value C_p. As declared in the previous Section 4.2.3, the air blast vulnerabilities are really close to zero and the casualties negligible. Both vulnerabilities and casualties for the best, expected and worst case-scenario can be seen in Table 4.25. In Figure 4.28 the vulnerabilities are portrayed and despite the varying distance and consequent pressure

Table 4.25: Medium asteroid overpressure vulnerability and respective causalities

		best		expected		worst	
Municipality	D $[km]$	$V_p \times 10^5$	C_p	$V_p \times 10^5$	C_p	$V_p \times 10^5$	C_p
Aveiro	715.2	3.36	2	2.32	1	4.40	3
Beja	807.1	3.36	1	2.32	0	4.39	1
Braga	751.6	3.36	6	2.32	4	4.40	7
Bragança	892.5	3.36	1	2.32	0	4.39	1
Castelo Branco	809.2	3.36	1	2.32	1	4.39	2
Coimbra	730.5	3.36	4	2.32	3	4.40	5
Évora	789.7	3.36	1	2.32	1	4.39	2
Faro	837.9	3.36	2	2.32	1	4.39	2
Funchal	776.6	3.36	3	2.32	2	4.39	4
Guarda	830.1	3.36	1	2.32	0	4.39	1
Leiria	697.2	3.36	4	2.33	2	4.40	5
Lisboa	681.3	3.36	17	2.33	11	4.40	22
Ponta Delgada	784.5	3.36	2	2.32	1	4.39	2
Portalegre	818.0	3.36	0	2.32	0	4.39	0
Porto	726.5	3.36	7	2.32	5	4.40	9
Santarém	711.4	3.36	1	2.32	1	4.40	2
Setúbal	705.3	3.36	3	2.32	2	4.40	5
Viana do Castelo	722.5	3.36	2	2.32	1	4.40	3
Vila Real	800.9	3.36	1	2.32	1	4.39	2
Viseu	777.1	3.36	3	2.32	2	4.39	4

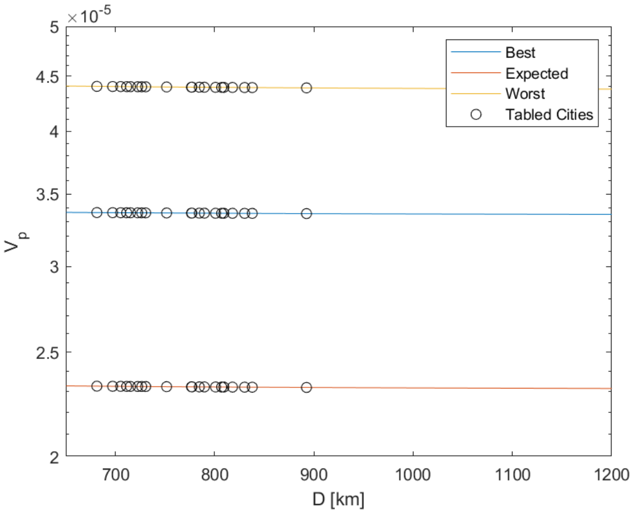

Figure 4.28: Medium Asteroid overpressure vulnerability as a function of the municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.2.3. The markers represent the values for the district capitals.

values between locations the vulnerability seen to remain unchanged. This can be explained by the low absolute pressure values inputted in the vulnerability model. The vulnerabilities are practically zero, the casualties have only some non-zero values because the population's number order of magnitude is the opposite of the vulnerability's. Considering a population of a million people (10^6), if we have a vulnerability of 10^{-6} the casualties will equate to 1, if we have a vulnerability of 10^{-5} the number rises to 10. These values are purely mathematical and as the pressure and vulnerabilities are low, the casualties can be neglected.

4.2.8.3 Thermal Radiation

The fireball radius generated by the Medium Asteroid's impact is not wide enough encompass any studied locality. The vast distance between the impact site and each municipality and the curvature of the Earth serves as a shield from the thermal radiation. As every location is not exposed directly to the radiation, and this model does not emulate radiation reflection or refraction of any kind, the vulnerabilities associated along with the casualties will be zero.

4.2.8.4 Ejecta Blanket Deposition

Ejecta is, by definition, ejected material from the impact site during the excavation of the crater. If it was already established the neglectful nature of the Medium Asteroid's crater formation at the bottom of the sea, the ejected material will be null along with the vulnerabilities and casualties. Despite this last statement, in Table 4.26 the vulnerabilities V_e and casualties C_e are displayed. The vulnerability value remain unchanged for every location and its absolute value is clearly zero, as the highest vulnerability value is in the -8 magnitude order. This is corroborated visually by Figure 4.29 and by consulting Table D.2.4 where all the municipalities studied are shown.

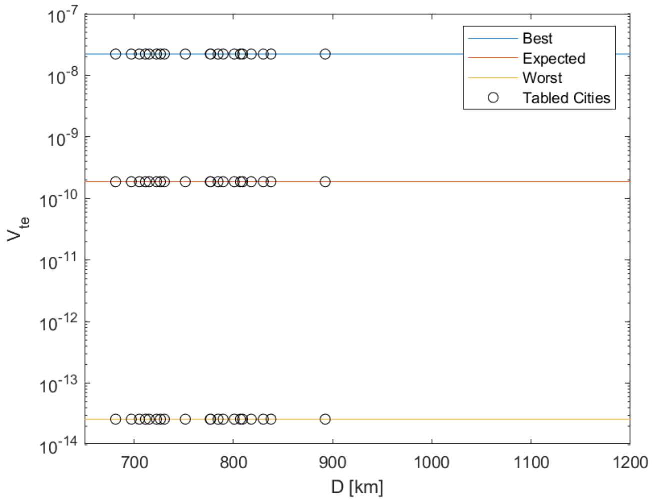

Figure 4.29: Medium Asteroid ejecta blanket deposition vulnerability as a function of the municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.2.4. The markers represent the values for the district capitals.

Table 4.26: Medium asteroid ejecta blanket deposition vulnerability and respective causalities

		best		expected		worst	
Municipality	D $[km]$	$V_e \times 10^8$	C_e	$V_e \times 10^{10}$	C_e	$V_e \times 10^{14}$	C_e
Aveiro	715.2	2.21	0	1.87	0	2.60	0
Beja	807.1	2.21	0	1.87	0	2.60	0
Braga	751.6	2.21	0	1.87	0	2.60	0
Bragança	892.5	2.21	0	1.87	0	2.60	0
Castelo Branco	809.2	2.21	0	1.87	0	2.60	0
Coimbra	730.5	2.21	0	1.87	0	2.60	0
Évora	789.7	2.21	0	1.87	0	2.60	0
Faro	837.9	2.21	0	1.87	0	2.60	0
Funchal	776.6	2.21	0	1.87	0	2.60	0
Guarda	830.1	2.21	0	1.87	0	2.60	0
Leiria	697.2	2.21	0	1.87	0	2.60	0
Lisboa	681.3	2.21	0	1.87	0	2.60	0
Ponta Delgada	784.5	2.21	0	1.87	0	2.60	0
Portalegre	818.0	2.21	0	1.87	0	2.60	0
Porto	726.5	2.21	0	1.87	0	2.60	0
Santarém	711.4	2.21	0	1.87	0	2.60	0
Setúbal	705.3	2.21	0	1.87	0	2.60	0
Viana do Castelo	722.5	2.21	0	1.87	0	2.60	0
Vila Real	800.9	2.21	0	1.87	0	2.60	0
Viseu	777.1	2.21	0	1.87	0	2.60	0

4.2.8.5 Tsunami

To conclude the vulnerability assessment of the Medium Asteroid, the vulnerabilities V_{tsu} and casualties C_{tsu} of each of the three waves was calculated. In Tables 4.27 and 4.28 are displayed the values for both Rumpf and Collins rim-wave amplitude methods, respectively.

Comparing both methods the similarities become evident. All the vulnerabilities values for

Table 4.27: Medium Asteroid's tsunami vulnerability and respective causalities, for Rumpf rim-wave method

		best		expected		worst	
Municipality	D $[km]$	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
Aveiro	715.2	0.014	1063	0.041	3158	0.099	7687
Beja	807.1	0.000	0	0.000	0	0.000	0
Braga	751.6	0.000	0	0.000	0	0.000	0
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.000	0	0.000	0	0.000	0
Coimbra	730.5	0.000	0	0.000	0	0.000	0
Évora	789.7	0.000	0	0.000	0	0.000	0
Faro	837.9	0.013	771	0.046	2800	0.125	7596
Funchal	776.6	1.000	104128	1.000	104128	1.000	104129
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	0.014	1732	0.050	6295	0.135	16900
Lisboa	681.3	0.031	15585	0.093	47306	0.208	105546
Ponta Delgada	784.5	0.187	12674	0.728	49372	0.930	63097
Portalegre	818.0	0.000	0	0.000	0	0.000	0
Porto	726.5	0.012	2573	0.038	8133	0.096	20717
Santarém	711.4	0.000	0	0.000	0	0.000	0
Setúbal	705.3	0.032	3665	0.125	14441	0.304	35136
Viana do Castelo	722.5	0.022	1870	0.112	9505	0.316	26730
Vila Real	800.9	0.000	0	0.000	0	0.000	0
Viseu	777.1	0.000	0	0.000	0	0.000	0

Table 4.28: Medium Asteroid's tsunami vulnerability and respective causalities, for Collins rim-wave method

		best		expected		worst	
Municipality	D $[km]$	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
Aveiro	715.2	0.012	911	0.036	2769	0.089	6923
Beja	807.1	0.000	0	0.000	0	0.000	0
Braga	751.6	0.000	0	0.000	0	0.000	0
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.000	0	0.000	0	0.000	0
Coimbra	730.5	0.000	0	0.000	0	0.000	0
Évora	789.6	0.000	0	0.000	0	0.000	0
Faro	837.9	0.011	668	0.040	2417	0.109	6658
Funchal	776.6	1.000	104125	1.000	104128	1.000	104128
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	0.012	1482	0.043	5373	0.118	14676
Lisboa	681.3	0.024	12080	0.074	37588	0.173	87758
Ponta Delgada	784.5	0.121	8181	0.578	39206	0.864	58661
Portalegre	818.0	0.000	0	0.000	0	0.000	0
Porto	726.5	0.010	2244	0.033	7193	0.087	18712
Santarém	711.4	0.000	0	0.000	0	0.000	0
Setúbal	705.3	0.024	2830	0.096	11128	0.245	28406
Viana do Castelo	722.5	0.018	1510	0.087	7403	0.255	21564
Vila Real	800.9	0.000	0	0.000	0	0.000	0
Viseu	777.1	0.000	0	0.000	0	0.000	0

any given location are identical. The values resultant from Rumpf's amplitude method entail slightly higher values due to also slightly higher amplitude values. All vulnerability values for all location are portrayed in a scatter plot in Figures 4.30 and 4.31 where the different case-scenarios: best, expected and worst, are depicted.

The most affected locations are the islands, more precisely Madeira. The islands will consistently entail the highest tsunami vulnerability values due to its volcanic nature and most exposed shoreline. Madeira island has, for any model and case-scenario an alarming vulnerability of one, meaning that every inhabitant of this municipality would fall victim of a Medium Asteroid-induced tsunami. Apart from the islands, the affected locations include only coast municipalities.

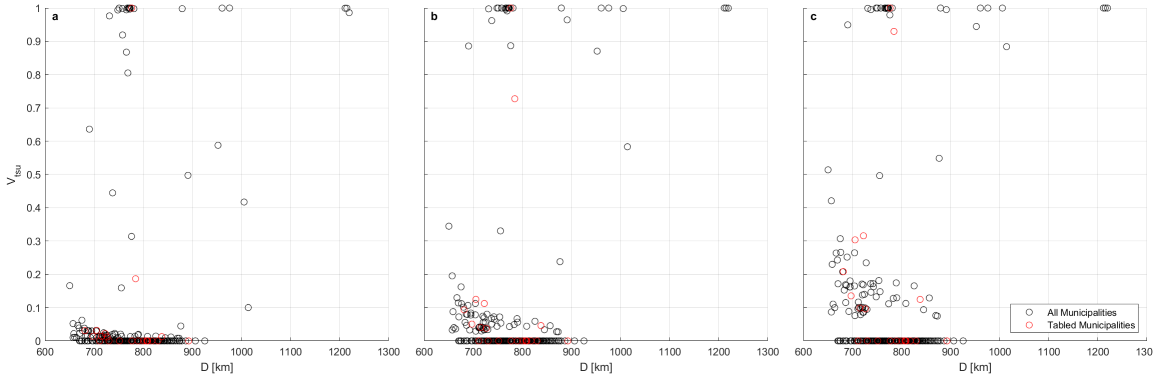

Figure 4.30: Medium Asteroid Rumpf's rim-wave vulnerability best (a), expected (b) and worst case-scenario (c) as a function of the municipalities' distance. The complete data is displayed in Table D.2.5. The red markers represent the values for the district capitals.

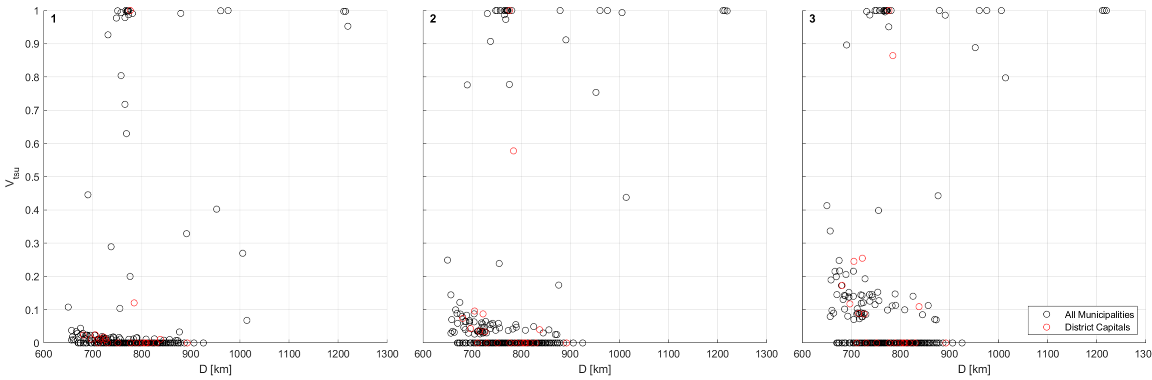

Figure 4.31: Medium Asteroid Collins' rim-wave vulnerability best (a), expected (b) and worst case-scenario (c) as a function of the municipalities' distance. The complete data is displayed in Table D.2.5. The red markers represent the values for the district capitals.

The final tsunami wave assessed was the collapse wave. The correspondent vulnerability and casualty values are shown in Table 4.29 and visually, for all municipalities, in Figure 4.32. The relative hazard of the rim and collapse waves was already discussed. Except Madeira, which the worst-case scenario reaches vulnerabilities of approximately 35% with a run-up wave of 1.85 meters; the municipalities entail low vulnerabilities due to also low run-up waves but significant casualty numbers. Once again, this can be explained by the large population density. However, it does not make physical sense a run-up height of 26 centimetres, in the case of Azores island, to induce 4000 casualties in the worst-case scenario. To better emulate reality this vulnerability models should have a low bound, based on experimental data, to assess the minimal run-up wave height possible of destruction.

Table 4.29: Medium Asteroid's collapse wave vulnerability and respective causalities

		best		expected		worst	
Municipality	D $[km]$	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
Aveiro	715.2	0.004	325	0.015	1137	0.043	3364
Beja	807.1	0.000	0	0.000	0	0.000	0
Braga	751.6	0.000	0	0.000	0	0.000	0
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.000	0	0.000	0	0.000	0
Coimbra	730.5	0.000	0	0.000	0	0.000	0
Évora	789.6	0.000	0	0.000	0	0.000	0
Faro	837.9	0.004	253	0.015	889	0.043	2636
Funchal	776.6	0.005	550	0.022	2341	0.073	7564
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	0.004	522	0.015	1829	0.043	5423
Lisboa	681.3	0.004	2151	0.015	7512	0.044	22212
Ponta Delgada	784.5	0.004	294	0.015	1046	0.046	3120
Portalegre	818.0	0.000	0	0.000	0	0.000	0
Porto	726.5	0.004	898	0.015	3137	0.043	9290
Santarém	711.4	0.000	0	0.000	0	0.000	0
Setúbal	705.3	0.004	490	0.015	1721	0.044	5103
Viana do Castelo	722.5	0.004	356	0.015	1255	0.044	3732
Vila Real	800.9	0.000	0	0.000	0	0.000	0
Viseu	777.1	0.000	0	0.000	0	0.000	0

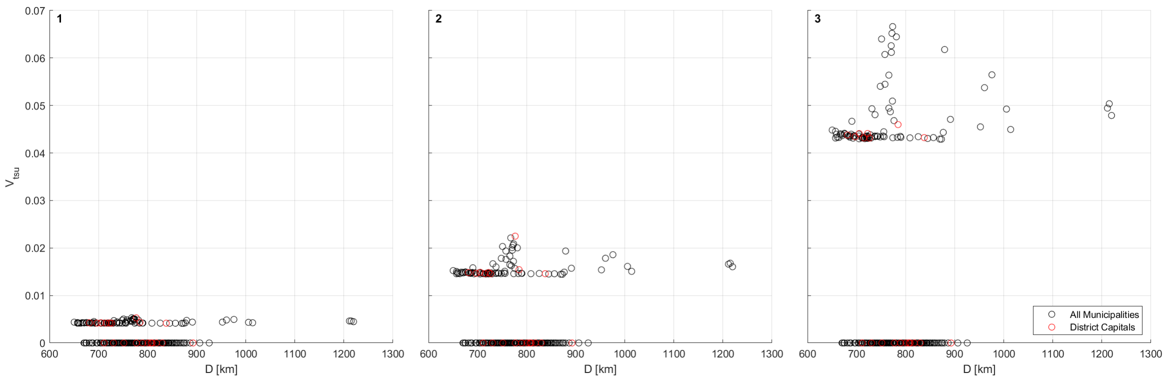

Figure 4.32: Medium Asteroid collapse wave best (a), expected (b) and worst case-scenario (c) vulnerability as a function of the municipalities' distance. The complete data is displayed in Table D.2.5. The red markers represent the values for the district capitals.

4.2.9 Timeline

In Lisbon, the effects experienced due to the Medium Asteroid impact are consistent with the Apophis' impact scenario. This means that Lisbon only experiences shock waves and tsunami waves. Figure 4.33 is a visual representation of the timeline of events. At the zero seconds mark occurs the Medium Asteroid's impact and subsequent crater formation, 33 minutes after the impact a shock wave of $473\ Pa$ hits Lisbon. The tsunami waves hit the coast approximately 2 hours and 23 minutes after the impact. The first wave has a run-up of $3.9\ m$. The second wave only has a run-up of $7.5\ cm$, barely noticeable.

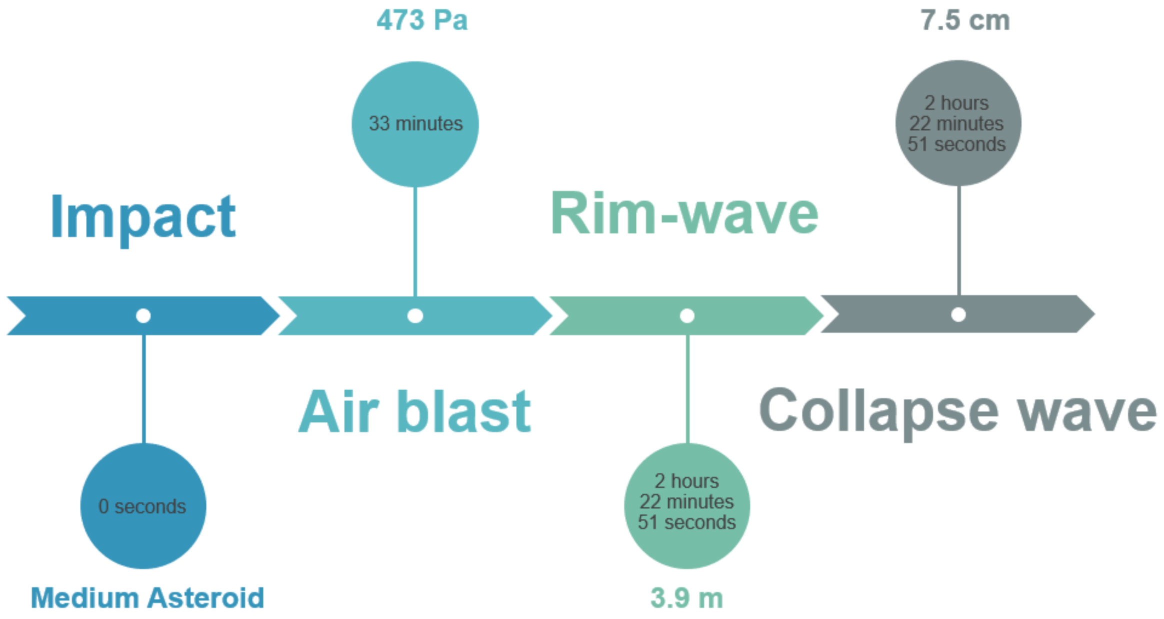

Figure 4.33: Medium Asteroid impact effects' timeline experienced in the capital of Portugal.

4.3 5km Impactor

To study what these models predict would happen in an apocalyptic scenario, an asteroid of 5 km in diameter was added to the simulation albeit impacts of this magnitude only happen approximately once every twenty million years. In Table 4.30 the paramount impact properties can be found either for the surface impact or the sea floor impact. The asteroid's density was set at $2500\ kg/m^3$ considering the average density for a sedimentary rock tabled by Rumpf in [23]. In terms of velocity, the impact value was set at $15\ km/s$ due to this being the threshold value for vaporization to occur and consequently induced thermal radiation as stated by Collins *et al.* in [15]. The 5 km asteroid impacts the ocean with a 4.91 km depth, the almost one-to-one relation between these values suggest that the water layer will not be as big a factor in attenuating the impact. Wünnemann *et al.* in [17] goes as far as stating that with a ratio of 0.982 between the depth and diameter, the impact would correspond to a shallow water impact.

Table 4.30: 5km Impactor physical and impact properties

	$L\ [m]$	$\theta\ [°]$	$\rho_i\ [kg/m^3]$	$v_i\ [m/s]$	$E\ [J]$
Surface	5000	45	2500	15000	1.841×10^{22}
Sea floor				7223	4.258×10^{21}

4.3.1 Crater Dimensions

Due to the large diameter of the asteroid the impact scenario is regarded as a shallow water impact and the results must be discussed accordingly. In shallow waters, some authors dismiss the formation of 2 different craters due to the minor gap between the water depth and the asteroid's diameter, this assumption can be found in the work of Wünnemann *et al.* regarding ocean impacts by cosmic bodies. However, for demonstration purposes, in this work the formation both theoretical craters will be considered. In Table 4.31 the dimensions of the craters can be found. The respective visual representation is shown in Figures 4.34 and 4.35.

The water transient crater spans a massive $52.7\ km$ from rim to rim which suggest the potential damage to the landscape and population if such an impact were to happen in a densely populated area. However, the crater depth is three times as deep as the ocean. For a surface transient crater this is an impossibility without benthic strata excavation, which refers to its theoretical nature.

Table 4.31: 5km Impactor craters dimensions

	$D_{tc}\ [m]$	$d_{tc}\ [m]$	$V_{tc}\ [m^3]$	Type	$D_{fr}\ [m]$	$d_{fr}\ [m]$	$h_{fr}\ [m]$	$t_{br}\ [m]$
Surface	5.27×10^4	1.49×10^4	2.04×10^{13}	Complex	8.88×10^4	1.22×10^1	–	–
Sea floor	2.40×10^4	8.47×10^3	1.91×10^{12}	Simple	3.00×10^4	6.38×10^3	8.59×10^2	2.96×10^3

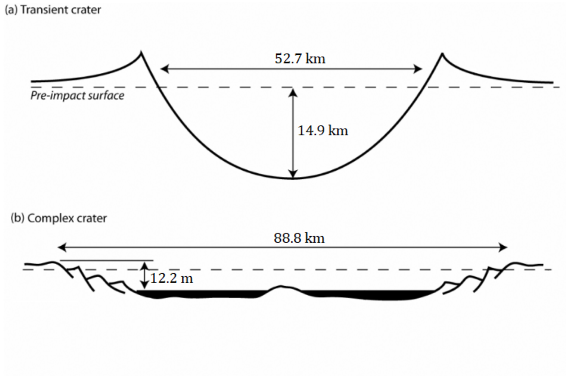

Figure 4.34: 5km Impactor's crater dimensions for the surface transient crater (a) and complex final crater (b).

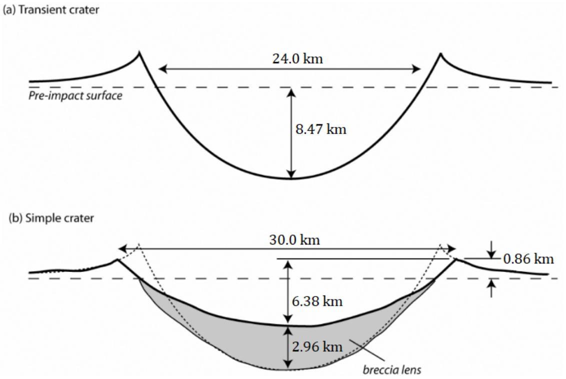

Figure 4.35: 5km Impactor's crater dimensions for the sea floor transient crater (a) and simple final crater (b).

4.3.2 Seismic Shaking

The impact-induced seismic shaking was a dire $M = 8.62$ on the Ritcher scale which can be loosely compared to the 1755 Lisbon earthquake in terms of absolute magnitude, with an estimated value of 8.4, albeit the distance between Lisbon and the epicentral point was roughly 300 kilometres, less than half the distance D between Lisbon and the impact point. Distance plays a huge role in attenuating the seismic waves felt throughout Portugal. As can be seen in Table 4.32, most municipalities experience an effective magnitude M_{eff} of around 3.8, less than half the absolute value. Consulting the Table A.1.1 and A.1.2 in Appendix A we can convert this average magnitude to qualitative terms. In the Mercalli scale the correspondent intensity would be around III and IV.

Table 4.32: 5km Impactor-induced seismic shaking effective magnitude for the district capitals' municipalities

Municipality	D $[km]$	M_{eff}
Aveiro	715.2	3.80
Beja	807.1	3.71
Braga	751.6	3.76
Bragança	892.5	3.64
Castelo Branco	809.2	3.71
Coimbra	730.5	3.78
Évora	789.7	3.73
Funchal	776.6	3.74
Faro	837.9	3.69
Guarda	830.1	3.69
Leiria	697.2	4.11
Lisboa	681.3	4.19
Ponta Delgada	784.5	3.73
Portalegre	818.0	3.70
Porto	726.5	3.79
Santarém	711.4	3.80
Setúbal	705.3	3.81
Viana do Castelo	722.5	3.79
Vila Real	800.9	3.72
Viseu	777.1	3.74

In Figure 4.36 are represented the effective magnitude values for all studied locations. The maximum value still is shy of half the absolute magnitude value. Even though the seismic shaking event produced by the 5km Impactor ban be compared to the 1755 Lisbon earthquake due to similar absolute magnitudes, the larger distances between the impact site and the locations downgrade the effective magnitudes.

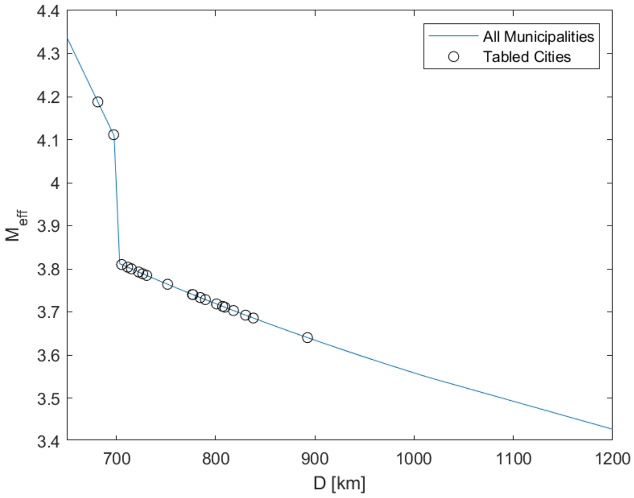

Figure 4.36: 5km Impactor effective magnitude as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.1. The markers represent the values for the district capitals.

4.3.3 Air blast

Assessing the 5km Impactor-induced shock wave through equation 2.25 requires first the yield-scaled distance estimation D_1. The distance D_1 represents the distance to a $1Mt$ ex-

Table 4.33: Yield-scaled distance and the respective overpressure per district capital for the Medium 5km Impactor case

Municipality	$D\ [km]$	$D_1\ [km\ kt^{-1/3}]$	$P_D\ [kPa]$
Aveiro	715.2	436.5	34.43
Beja	807.1	492.5	27.68
Braga	751.6	458.7	31.45
Bragança	892.5	544.7	23.18
Castelo Branco	809.2	493.9	27.54
Coimbra	730.5	445.8	33.12
Évora	789.7	481.9	28.77
Faro	837.9	511.3	25.90
Funchal	776.6	474.0	29.64
Guarda	830.1	506.6	26.32
Leiria	697.2	425.5	36.07
Lisboa	681.3	415.8	37.64
Ponta Delgada	784.5	478.8	29.11
Portalegre	818.0	499.2	27.02
Porto	726.5	443.4	33.45
Santarém	711.4	434.1	34.76
Setúbal	705.3	430.4	35.31
Viana do Castelo	722.5	440.9	33.79
Vila Real	800.9	488.7	28.06
Viseu	777.1	474.2	29.61

plosion that experiences the same overpressure effects as the distance D to the impact site experiences, given an impact energy E. Given a singular distance D_1 value for every municipality the overpressure P_D can be assessed. Both the distance D_1 and the pressure P_D are shown in Table 4.33, along with the distance D to the impact site. The tabled values correspond to the district capitals' municipalities and not the entire district. In Figure 4.37 are depicted the results for all studied municipalities that originate from Table D.3.1. The results are in the low dozens of kilopascals which is not a major pressure difference but still enough for the effects to be experienced. The qualitative effects can be seen in Table A.3.1. Most locations will experience glass windows shattering, roofs will be severely damaged and wood frame buildings will almost completely collapse. In the most affected locations, multi-story wall-bearing buildings can experience severe cracking and interior partitions can be blown down.

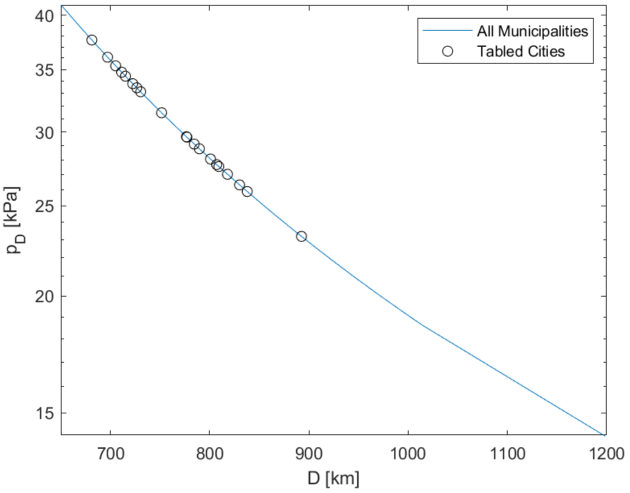

Figure 4.37: 5km Impactor overpressure as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.1. The markers represent the values for the district capitals.

4.3.4 Thermal Radiation

To assess thermal radiation effects on any location by any celestial object, the fireball dimensions needs to be assessed first. Ultimately, the fireball will be the deliverer of the thermal radiation effects. Any other energy transfer method will be dismissed, such as atmospheric reflection. With equation 2.27, the estimated 5km Impactor generated fireball has a $R_f = 5.281 \times 10^4\ m$ radius.

The ensuing calculation is obtaining two ratios for every location. The first one is the maximum height of the fireball below the horizon h over the fireball radius R_f. If this ratio h/R_f is less than the unity it means that the entire fireball is below the horizon and the location in question is not exposed to the radiation. The second ratio is the fraction of visible fireball over the horizon f. If this value is zero, the location is completely shielded from direct thermal radiation. On the other hand, if the value is one the location is so close to the impact site

Table 4.34: Distance to the impact site D, maximum height of the fireball below the horizon over the fireball radius h/R_f, fraction of visible fireball above the horizon, upper and lower thermal radiation generated by the 5km Impactor collision

Municipality	D $[km]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$
Aveiro	715.2	0.759	0.136	7.819	78.19
Beja	807.1	0.967	0.007	0.326	3.262
Braga	751.6	0.839	0.076	3.940	39.40
Bragança	892.5	1.182	0.000	0.000	0.000
Castelo Branco	809.2	0.972	0.006	0.251	2.513
Coimbra	730.5	0.792	0.110	6.047	60.47
Évora	789.7	0.926	0.024	1.134	11.34
Faro	837.9	1.042	0.000	0.000	0.000
Funchal	776.6	0.895	0.040	1.944	19.44
Guarda	830.1	1.023	0.000	0.000	0.000
Leiria	697.2	0.722	0.169	10.17	101.7
Lisboa	681.3	0.689	0.198	12.50	125.0
Ponta Delgada	784.5	0.914	0.030	1.434	14.34
Portalegre	818.0	0.993	0.001	0.031	0.307
Porto	726.5	0.784	0.117	6.487	64.87
Santarém	711.4	0.751	0.143	8.293	82.93
Setúbal	705.3	0.739	0.154	9.073	90.73
Viana do Castelo	722.5	0.775	0.124	6.945	69.45
Vila Real	800.9	0.952	0.013	0.574	5.737
Viseu	777.1	0.896	0.039	1.913	19.13

that the Earth's curvature can be disregarded, and the location experiences the full force of the thermal radiation.

To complete the assessment all that remains is the computation of the actual thermal radiation value with equation 2.28. The thermal radiation is but a fraction of the total kinetic energy released upon impact. This fraction, the luminous efficiency η_{lum}, ranges from 10^{-4} and 10^{-2}. The threshold values were the ones used to define the lower thermal radiation ϕ^- and upper thermal radiation ϕ^+ in the present work. All the variables are shown in Table 4.34, along with the distance D to the impact site, for the district capitals' municipalities. In Figure 4.38 the results are depicted graphically for all studied municipalities. These results originate from Table D.3.1. For any location, the difference between upper and lower thermal radiation is two complete orders of magnitude, which is intrinsically related with the luminous efficiency, as this fraction limits also ranges from two orders of magnitude. It can be observed that from a distance $D = 820.9\ km$ onwards, no thermal radiation is experienced. For any municipality with a higher distance value, the fraction h/R_f is greater than one and all subsequent values are zero.

Given the thermal radiation values for any given location, the qualitative impact effects of the radiation can be estimated by comparison with Table A.2.1. In Table 4.35 lies this comparison for the district capitals. These are the potential effects' damage in the capitals as municipalities and not on the entire districts. The ignited materials depicted in the table are the potential damages to the location assuming the highest thermal radiation ϕ^+ possible. This comparison was also made with the lower thermal radiation ϕ^- and no materials were

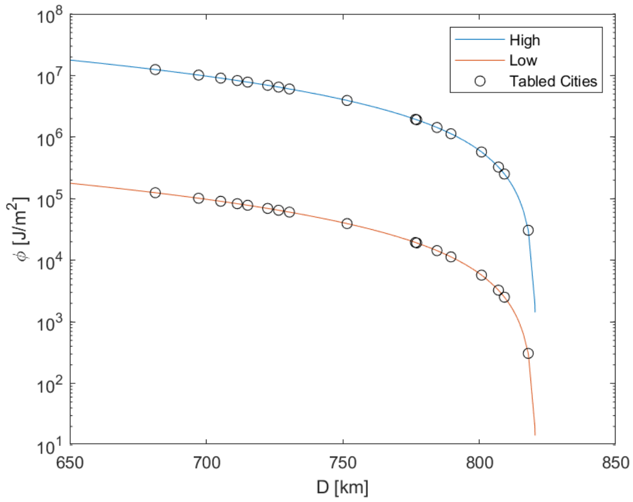

Figure 4.38: 5km Impactor upper and lower thermal radiation as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.1. The markers represent the values for the district capitals.

ignited, nor first degree burns were experienced. In conclusion, any location qualitative thermal radiation damage can vary from no ignited materials to the respective ignited materials tabled description depending on the luminous efficiency considered.

Table 4.35: 5km Impactor qualitative thermal radiation damage.

Municipality	Ignited Materials
Aveiro	Grass, newspaper, deciduous trees, and third-degree burns
Beja	No ignited materials
Braga	Deciduous trees, and second-degree burns
Bragança	No ignited materials
Castelo Branco	No ignited materials
Coimbra	Grass, newspaper, deciduous trees, and third-degree burns
Évora	No ignited materials
Faro	No ignited materials
Funchal	First-degree burns
Guarda	No ignited materials
Leiria	Plywood, grass, newspaper, deciduous trees, and third-degree burns
Lisboa	Plywood, grass, newspaper, deciduous trees, and third-degree burns
Ponta Delgada	No ignited materials
Portalegre	No ignited materials
Porto	Grass, newspaper, deciduous trees, and third-degree burns
Santarém	Grass, newspaper, deciduous trees, and third-degree burns
Setúbal	Plywood, grass, newspaper, deciduous trees, and third-degree burns
Viana do Castelo	Grass, newspaper, deciduous trees, and third-degree burns
Vila Real	No ignited materials
Viseu	First-degree burns

4.3.5 Ejecta

The ejected material from the crater is of a simpler assessment. Both the mean ejecta fragment diameter L_e and the ejecta blanket thickness t_e can be obtained by the direct relations presented in equations 2.31 and 2.32 respectively. Being the latter further used in the ejecta vulnerability assessment. In Table 4.36 the distance D, the mean ejecta fragment diameter L_e and the ejecta blanket thickness t_e values are presented for the district capitals. These results are plotted in Figures 4.39 and 4.40 divided into the mean ejecta fragment diameter L_e and the ejecta blanket thickness t_e variation over the distance D. The capitals represent only the municipality in question and not the entire district. The complete results with all municipalities can be accessed in Appendix D on Table D.3.1.

Table 4.36: Mean ejecta fragment diameter and ejecta blanket thickness resultant from the 5km Impactor collision with the ocean floor

Municipality	D $[km]$	$L_e[mm]$	$t_e[mm]$
Aveiro	715.2	1.063	8.050
Beja	807.1	0.772	5.601
Braga	751.6	0.932	6.936
Bragança	892.5	0.591	4.141
Castelo Branco	809.2	0.766	5.556
Coimbra	730.5	1.005	7.554
Évora	789.7	0.818	5.980
Faro	837.9	0.699	5.006
Funchal	776.6	0.855	6.286
Guarda	830.1	0.716	5.147
Leiria	697.2	1.138	8.689
Lisboa	681.3	1.209	9.310
Ponta Delgada	784.5	0.832	6.098
Portalegre	818.0	0.745	5.380
Porto	726.5	1.020	7.679
Santarém	711.4	1.079	8.180
Setúbal	705.3	1.103	8.393
Viana do Castelo	722.5	1.035	7.808
Vila Real	800.9	0.788	5.733
Viseu	777.1	0.853	6.275

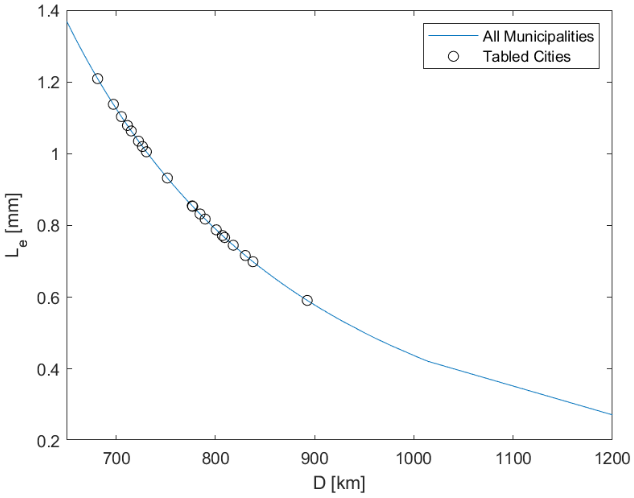

Figure 4.39: 5km Impactor mean ejecta fragment diameter as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.1. The markers represent the values for the district capitals.

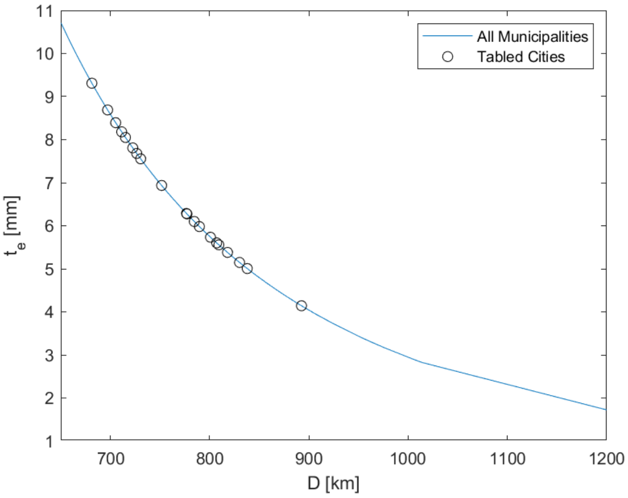

Figure 4.40: 5km Impactor ejecta blanket thickness as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.1. The markers represent the values for the district capitals.

4.3.6 Tsunami

The 5km asteroid oceanic impact is considered a shallow water impact due to the asteroid diameter over ocean depth ratio L_0/h_{sea}. Wünnemann *et al.* in [17] stated that for such scenarios a collapse wave would not form and the only tsunami threat would be only the creation and propagation of the rim-wave. Therefore, the collapse wave was completely disregarded in this asteroid's impact and the tsunami assessment was only made with two already mentioned rim-wave methods. The difference in these methods, Rumpf's in [23] and Collins' in [16], is only the wave amplitude attenuation equation used. For Rumpf's method the equation 2.37 was used, and for Collins' method the equation 2.39 was considered instead. As for the subsequent estimations, the maximum U_{max} and minimum run-up U_{min} wave calculation approach was the same for both amplitude methods. In Tables 4.37 and 4.38 all the relevant values are shown for Rumpf's and Collins' method, respectively.

The wave amplitude propagation depends heavy on the ocean bathymetry. However, both methods used in this work manage to provide good estimations for the amplitude in deep waters, according to comparison to experimental data made by the authors. Rumpf in [23] claims that the threshold between shallow and deep waters lies in the 800-metre depth point which gives this point extra importance. Since the waters near the coast are less than 800 metres deep and considered shallow, these amplitude methods lose their validity. Thus, Rumpf developed a run-up wave computation approach to assess the evolution of the waves near the coast and its final height on the coastline. This method was slightly adjusted to fit the needs of this study, which is explained in detail in Section 2.8.3.

The paramount variable in the tsunami hazard assessment is the run-up wave at the coastline. So, the main concern of the estimation is the shallow water wave behaviour. To assess the run-up wave height, *i.e.,* the height the wave can reach inland and not the wave height

Table 4.37: Distance to the shore from the 800 m depth point, wave amplitude at this point and run-up heights due to the 5km Impactor, for the rim-wave method depicted by Rumpf

Municipality	$D\ [km]$	$D_{shore}\ [km]$	$A_{800}\ [m]$	$U_{min}\ [m]$	$U_{max}\ [m]$
Aveiro	715.2	127	194.7	102.5	112.5
Beja	807.1	70	190.4	41.17	54.09
Braga	751.6	220	190.0	74.34	124.1
Bragança	892.5	191	192.5	32.59	66.31
Castelo Branco	809.2	115	209.4	32.05	70.54
Coimbra	730.5	199	210.4	46.86	75.31
Évora	789.7	49	203.4	40.67	53.13
Faro	837.9	3.1	164.1	96.07	145.3
Funchal	776.6	14	167.4	1534	5018
Guarda	830.1	184	200.4	43.85	73.75
Leiria	697.2	50	200.1	103.9	157.2
Lisboa	681.3	30	198.8	172.7	221.9
Ponta Delgada	784.5	50	168.0	340.2	711.5
Portalegre	818.0	188	205.5	36.78	63.99
Porto	726.5	56	193.1	91.18	109.1
Santarém	711.4	130	222.7	42.34	70.08
Setúbal	705.3	29	191.5	175.3	285.1
Viana do Castelo	722.5	35	188.3	144.1	292.3
Vila Real	800.9	127	192.1	46.37	107.8
Viseu	777.1	121	197.3	53.33	90.60

per se, the wave amplitude at the 800-metre point A_{800} and the distance from this point to the shore D_{shore} are needed. The run-up value obtained with equation 2.43 cannot be directly used in the vulnerability models as it assumes the location in question is at sea level. Since most locations studied are not coastal municipalities a local run-up must be calculated to obtain a maximum run-up wave height U_{max} and a minimum run-up wave height U_{min}.

Table 4.38: Distance to the shore from the 800 m depth point, wave amplitude at this point and run-up heights due to the 5km Impactor, for rim-wave method depicted by Collins

Municipality	$D\ [km]$	$D_{shore}\ [km]$	$A_{800}\ [m]$	$U_{min}\ [m]$	$U_{max}\ [m]$
Aveiro	715.2	127	222.4	109.6	120.3
Beja	807.1	70	217.6	44.01	57.83
Braga	751.6	220	217.1	79.47	132.6
Bragança	892.5	191	220.0	34.84	70.88
Castelo Branco	809.2	115	239.3	34.26	75.41
Coimbra	730.5	199	240.4	50.10	80.50
Évora	789.7	49	232.4	43.48	56.79
Faro	837.9	3.1	187.6	102.7	155.3
Funchal	776.6	14	191.3	1639	5365
Guarda	830.1	184	229.0	46.88	78.84
Leiria	697.2	50	228.6	111.1	168.1
Lisboa	681.3	30	227.2	184.6	237.2
Ponta Delgada	784.5	50	192.0	363.7	760.6
Portalegre	818.0	188	234.9	39.31	68.41
Porto	726.5	56	220.7	97.47	116.6
Santarém	711.4	130	254.5	45.26	74.91
Setúbal	705.3	29	218.8	187.4	304.8
Viana do Castelo	722.5	35	215.2	154.0	312.5
Vila Real	800.9	127	219.6	49.57	115.2
Viseu	777.1	121	225.5	57.00	96.85

All these values are present in the tables, along with the distance D to the impact site, for the district capitals. In Figure 4.41 lies a comparison between the two different amplitude attenuations methods used. A clear resemblance is evident. Both methods' outcomes have the same magnitude order with Collins' method producing slightly higher amplitudes. In this figure are plotted all studied municipalities twice, once for every amplitude method. In Figures 4.42 and 4.43 is depicted a comparison of the minimum and maximum local run-up wave heights generated by the different amplitude methods. As the amplitudes entail similarities, the ensuing run-ups are also similar. The data is plotted on a semi-logarithmic scale that encompasses all studied municipalities.

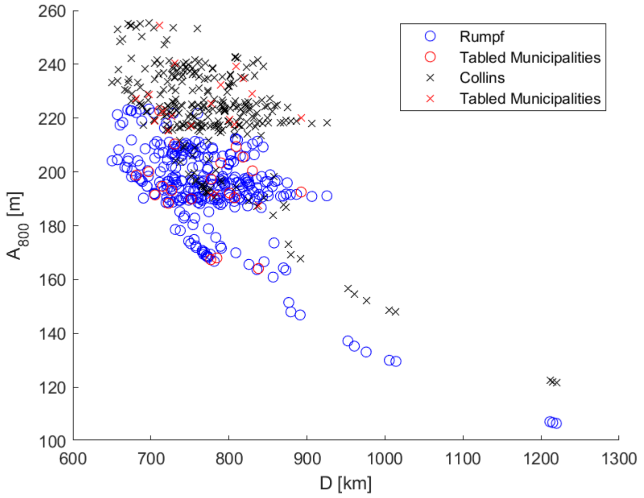

Figure 4.41: 5km Impactor-resulting rim wave amplitude at the 800 m depth point as a function of the municipalities distance. The different markers' colour and shape represent all municipalities for each method displayed in full in Table D.3.2. The red markers represent the values for the district capitals.

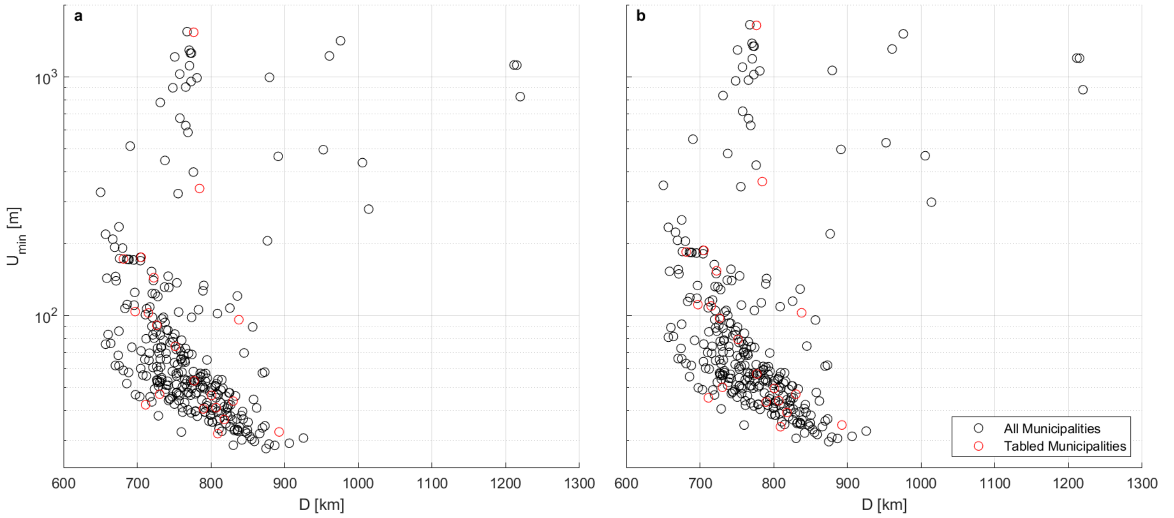

Figure 4.42: 5km Impactor-resulting minimum run up wave, for Rumpf's amplitude method (a) and Collins' (b), at the coast as a function of the municipalities' distance. The complete data is displayed in Table D.3.2. The red markers represent the values for the district capitals.

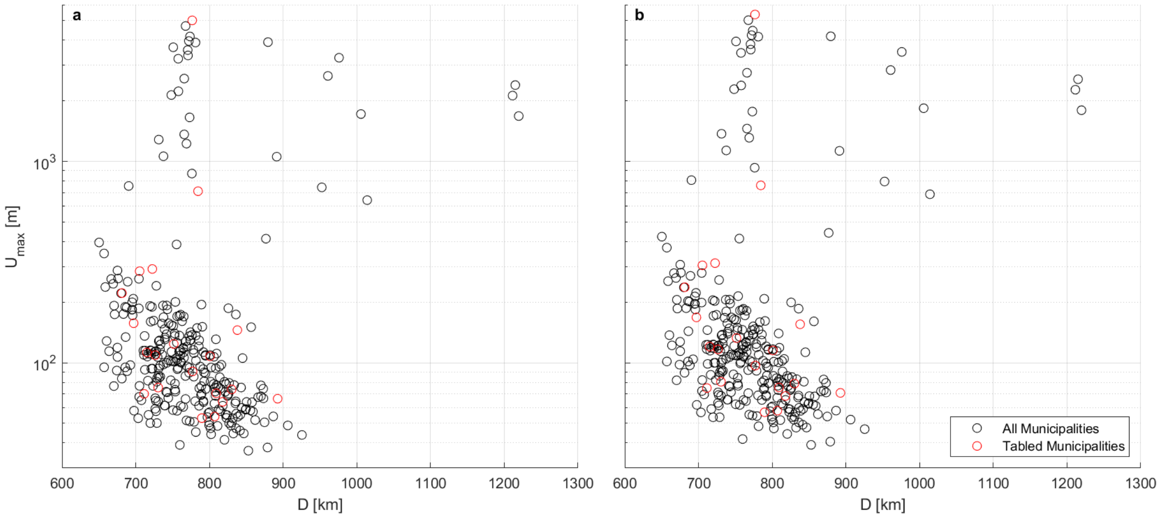

Figure 4.43: 5km Impactor-resulting maximum run up wave, for Rumpf's amplitude method (a) and Collins' (b), at the coast as a function of the municipalities' distance. The complete data is displayed in Table D.3.2. The red markers represent the values for the district capitals.

4.3.7 Global Effects

The 5km Impactor collision event induced a 67-microseconds change in the day total length. It is a perceptible order of magnitude given the circumstances, but it is not enough to make a change in the population's perception of the day. The global implications of the 5km Impactor collision event can be found in Table 4.39. This impact scenario, even though it entails significant impact effects, is not on a large enough scale to cause any global change in the Earth's orbit, rotation period, tilt of axis or mass.

Table 4.39: Global implications of the 5km Impactor collision event

Ratio	Value	Qualitative global change
$M_i/M_{♁}$	1.5×10^{-11}	No noticeable change in orbit.
$\Gamma_i/\Gamma_{♁}$	1.9×10^{-09}	No noticeable change in rotation period and tilt of axis.
$V_{tc}/V_{♁}$	1.8×10^{-09}	Earth is not strongly disturbed and loses negligible mass.

4.3.8 Vulnerability

In this subsection are displayed the individual vulnerabilities and respective casualties for each 5km Impactor's collision effect. The casualties are obtained as a simple product between the vulnerability and the population of a given location.

4.3.8.1 Seismic Shaking

The seismic shaking vulnerabilities are divided in three different case scenarios, best, expected, and worst. For each scenario, a vulnerability V_{seis} and subsequent casualties C_{seis} was computed. In Table 4.40 all three scenarios are shown for the district capitals along with the respective distance D to the impact site. In Figure 4.44 the three scenarios are shown for all studied municipalities. Even though the seismic shaking on the Ritcher scale was positive,

Table 4.40: 5km Impactor seismic shaking vulnerability and respective causalities for the district capitals' municipalities

		best		expected		worst	
Municipality	D $[km]$	$V_{seis} \times 10^7$	C_{seis}	$V_{seis} \times 10^6$	C_{seis}	$V_{seis} \times 10^7$	C_{seis}
Aveiro	715.2	4.936	0	4.585	0	5.402	0
Beja	807.1	3.967	0	3.682	0	3.880	0
Braga	751.6	4.512	0	4.190	0	4.715	0
Bragança	892.5	3.306	0	3.068	0	2.945	0
Castelo Branco	809.2	3.947	0	3.664	0	3.851	0
Coimbra	730.5	4.750	0	4.412	0	5.097	0
Évora	789.7	4.126	0	3.831	0	4.119	0
Faro	837.9	3.707	0	3.440	0	3.502	0
Funchal	776.6	4.252	0	3.948	0	4.310	0
Guarda	830.1	3.770	0	3.499	0	3.592	0
Leiria	697.2	10.78	1	10.04	0	17.62	0
Lisboa	681.3	13.05	6	12.16	0	23.53	1
Ponta Delgada	784.5	4.175	0	3.877	0	4.193	0
Portalegre	818.0	3.871	0	3.594	0	3.740	0
Porto	726.5	4.797	0	4.456	0	5.174	0
Santarém	711.4	4.984	0	4.630	0	5.481	0
Setúbal	705.3	5.061	0	4.702	0	5.611	0
Viana do Castelo	722.5	4.846	0	4.501	0	5.253	0
Vila Real	800.9	4.022	0	3.734	0	3.963	0
Viseu	777.1	4.247	0	3.944	0	4.303	0

this vulnerability model predicts zero casualties for a seismic shaking of this scale. The best-case scenario should produce the lowest vulnerability results and the worst-case scenario the higher vulnerability results. Due to the terminology issues mentioned in Chapter 3 this is not the case. This incoherence is not a big deal, it only means that the vulnerability results are outside the scope of the relevant vulnerability values envisioned by Rumpf *et al.* in [25].

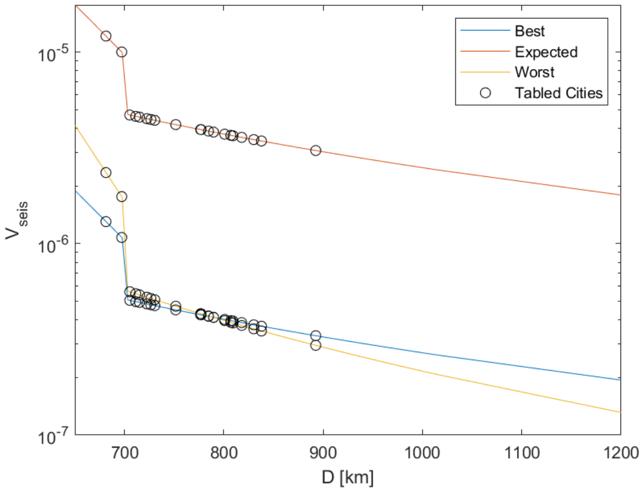

Figure 4.44: 5km Impactor seismic shaking vulnerability as a function of the district capitals' municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.3. The markers represent the values for the district capitals.

4.3.8.2 Air blast

Comparing the overpressure values experienced, Table D.3.1, against the qualitative pressure damage, Table A.3.1, a high casualty count would be expected. As mentioned in Section 4.3.3, most location would experience glass windows shattering, severely damage roofs and almost completely collapse of wood frame buildings. Using common sense as the judging tool the pressure vulnerabilities V_p and casualties C_p should entail higher absolute values. These values are shown in Table 4.41 for the district capitals' municipalities. Visually, in Figure

Table 4.41: 5km Impactor overpressure vulnerability and respective causalities

		best		expected		worst	
Municipality	D [km]	$V_p \times 10^5$	C_p	$V_p \times 10^5$	C_p	$V_p \times 10^5$	C_p
Aveiro	715.2	6.412	4	5.298	4	11.569	9
Beja	807.1	5.640	1	4.498	1	9.547	3
Braga	751.6	6.059	11	4.929	8	10.630	19
Bragança	892.5	5.179	1	4.033	1	8.400	2
Castelo Branco	809.2	5.626	2	4.484	2	9.511	4
Coimbra	730.5	6.255	8	5.133	6	11.147	14
Évora	789.7	5.759	3	4.619	2	9.850	5
Faro	837.9	5.453	3	4.308	2	9.075	5
Funchal	776.6	5.855	6	4.718	4	10.097	10
Guarda	830.1	5.497	2	4.353	1	9.187	3
Leiria	697.2	6.615	8	5.514	6	12.124	15
Lisboa	681.3	6.815	34	5.727	29	12.676	64
Ponta Delgada	784.5	5.796	3	4.657	3	9.946	6
Portalegre	818.0	5.571	1	4.427	0	9.371	2
Porto	726.5	6.294	13	5.174	11	11.253	24
Santarém	711.4	6.453	3	5.342	3	11.681	6
Setúbal	705.3	6.521	7	5.413	6	11.866	13
Viana do Castelo	722.5	6.335	5	5.217	4	11.362	9
Vila Real	800.9	5.681	2	4.540	2	9.652	4
Viseu	777.1	5.852	5	4.714	4	10.088	9

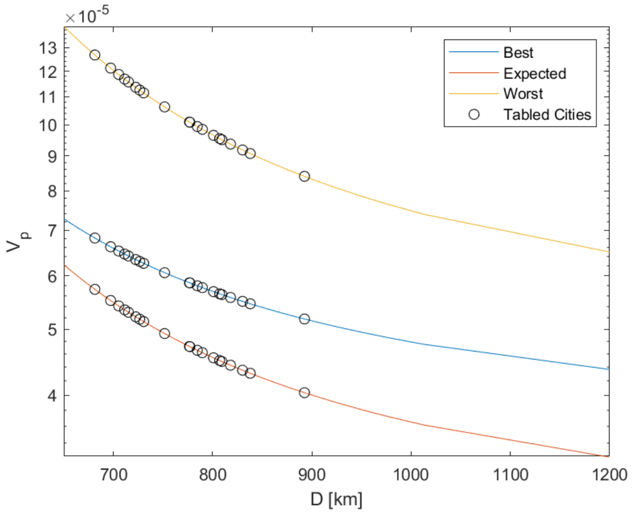

Figure 4.45: 5km Impactor overpressure vulnerability as a function of the district capitals' municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.3. The markers represent the values for the district capitals.

4.45, and in Table D.3.1 can be seen the full data where all municipalities studied are depicted.

One way to justify the lower absolute values given the qualitative damages is the pressure vulnerability validity range. By observing both the table and the figure we can see a discrepancy in the best and expected-case scenarios. They have swapped positions. The best-case scenario should entail the lowest vulnerability and casualties' values. This is clearly not the case and one logical explanation is that the 5km Impactor overpressure values lie outside the validity range for the pressure vulnerability model defined by Rumpf *et al.*

4.3.8.3 Thermal Radiation

The thermal radiation vulnerabilities besides being divided by case scenario: best, expected and worst, are also divided into lower V_{ϕ^-} and higher thermal radiation vulnerabilities V_{ϕ^+}. This division will also affect casualties, C_{ϕ^+} representing casualties for the higher thermal radiation vulnerabilities and C_{ϕ^-} for the lower thermal radiation vulnerabilities. These values are shown in Tables 4.42, for the upper thermal radiation limit, and 4.43 for the lower thermal radiation limit. This thermal radiation thresholds are due to the luminous efficiency, a ratio that defines the amount of kinetic energy that is converting into thermal radiation. In this study, the luminous efficiency values were set at 10^{-2} for the upper thermal radiation and at 10^{-4} for the lower thermal radiation. The tabled values are only represented by the district capitals. The values for all municipalities studied are displayed in Table D.3.4 and visually represented in Figure 4.46 for the upper thermal radiation, and Figure 4.47 for the lower thermal radiation.

Table 4.42: 5km Impactor thermal radiation upper limit vulnerability and respective causalities for the district capitals' municipalities

		best		expected		worst	
Municipality	D $[km]$	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^+}	C_{ϕ^+}
Aveiro	715.2	0.250	19479	0.470	36620	1.000	77916
Beja	807.1	0.023	778	0.044	1463	0.093	3112
Braga	751.6	0.250	45479	0.470	85501	1.000	181918
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.016	821	0.030	1543	0.063	3284
Coimbra	730.5	0.250	33430	0.470	62850	1.000	133723
Évora	789.7	0.226	11875	0.426	22326	0.906	47503
Faro	837.9	0.000	0	0.000	0	0.000	0
Funchal	776.6	0.250	26003	0.469	48887	0.999	104015
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	0.250	31214	0.470	58682	1.000	124857
Lisboa	681.3	0.250	126805	0.470	238393	1.000	507220
Ponta Delgada	784.5	0.245	16644	0.461	31291	0.981	66578
Portalegre	818.0	0.005	106	0.009	200	0.019	425
Porto	726.5	0.250	53820	0.470	101183	1.000	215283
Santarém	711.4	0.250	14349	0.470	26977	1.000	57398
Setúbal	705.3	0.250	28939	0.470	54406	1.000	115758
Viana do Castelo	722.5	0.250	21158	0.470	39778	1.000	84635
Vila Real	800.9	0.073	3633	0.137	6831	0.291	14535
Viseu	777.1	0.250	24216	0.469	45526	0.999	96864

Table 4.43: 5km Impactor thermal radiation lower limit vulnerability and respective causalities for the district capitals' municipalities

		best		expected		worst	
Municipality	$D\ [km]$	$V_{\phi^-} \times 10^3$	C_{ϕ^-}	$V_{\phi^-} \times 10^3$	C_{ϕ^-}	$V_{\phi^-} \times 10^3$	C_{ϕ^-}
Aveiro	715.2	6.183	481	11.625	905	24.733	1927
Beja	807.1	4.092	137	7.693	258	16.369	549
Braga	751.6	4.996	908	9.392	1708	19.984	3635
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	4.075	212	7.662	399	16.301	850
Coimbra	730.5	5.610	750	10.547	1410	22.440	3000
Évora	789.7	4.279	224	8.045	421	17.116	897
Faro	837.9	0.000	0	0.000	0	0.000	0
Funchal	776.6	4.475	465	8.413	876	17.900	1863
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	7.032	878	13.221	1650	28.130	3512
Lisboa	681.3	7.984	4049	15.009	7612	31.935	16197
Ponta Delgada	784.5	4.351	295	8.179	555	17.402	1180
Portalegre	818.0	4.026	90	7.569	169	16.103	360
Porto	726.5	5.748	1237	10.805	2326	22.990	4949
Santarém	711.4	6.346	364	11.931	684	25.385	1457
Setúbal	705.3	6.623	766	12.451	1441	26.493	3066
Viana do Castelo	722.5	5.894	498	11.081	937	23.576	1995
Vila Real	800.9	4.149	206	7.799	388	16.594	827
Viseu	777.1	4.467	433	8.399	814	17.869	1733

The thermal radiation is so far the biggest threat. For the worst-case scenario and the highest thermal radiation most location would experience a vulnerability of one. This means the casualties would equate to the total population of the area. However, the thermal radiation is highly susceptible to distance attenuation. For the 5km Impactor scenario the effects start to not be experienced from $D = 820.9\ km$ onwards. These results coupled with the previous asteroids' thermal radiation results corroborate the notion of thermal radiation being highly hazardous in the impact surrounding area.

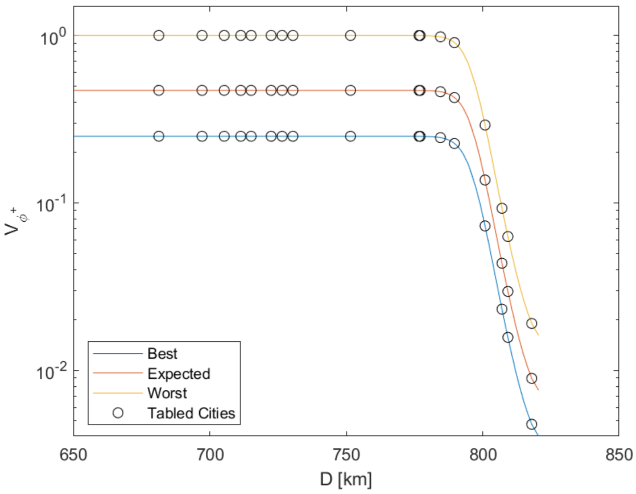

Figure 4.46: 5km Impactor upper thermal radiation vulnerability as a function of the district capitals' municipalities' distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.4. The markers represent the values for the district capitals.

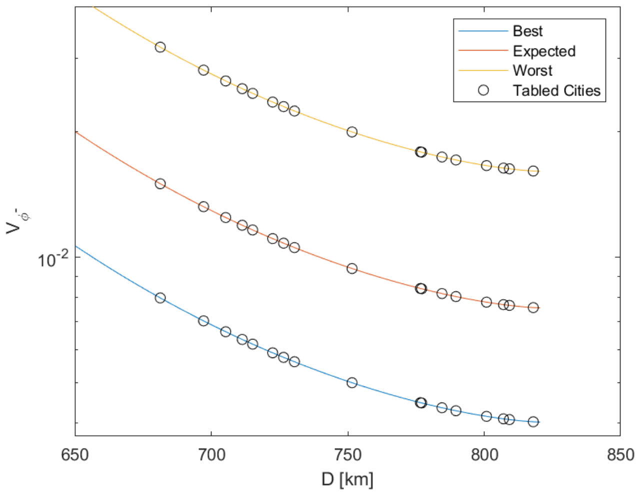

Figure 4.47: 5km Impactor lower thermal radiation vulnerability as a function of the municipalities distance. The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.4. The markers represent the values for the district capitals.

4.3.8.4 Ejecta Blanket Deposition

The ejecta vulnerability model is associated with collapsing buildings due to ejecta deposits on the roof or any upper bounding structure. The models are divided in three different case scenarios: best, expected, and worst, depending on the building strength assumed. So, if all infrastructures affected are assumed to be robust and not prone to collapse it is the best-case scenario. On the other hand, if the infrastructures are assumed to be fragile and easily destroyable it is the worst-case scenario. In Table 4.44 are shown the ejecta vulnerabilities V_e and casualties C_e for the district capitals. The tabled values are derived of the ejecta blanket thickness t_e value and correspond to only the municipality area and not the entire district. In Figure 4.48 can be seen a visual representation of the vulnerability results for all studied

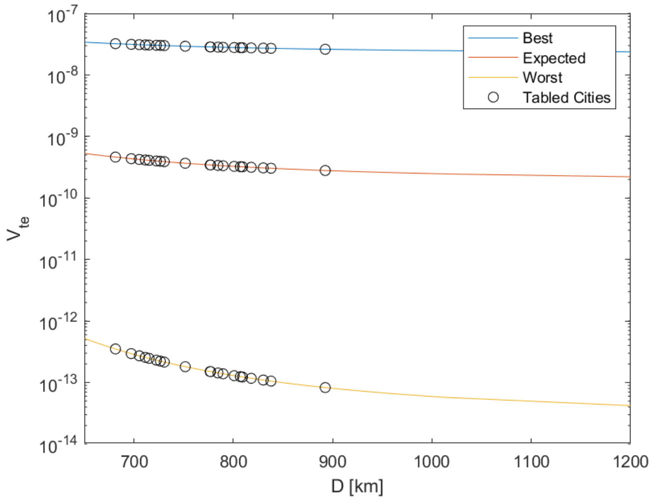

Figure 4.48: 5km Impactor ejecta blanket deposition vulnerability as a function of the municipalities distance.The values for all municipalities are represented with a continuous line, the discrete values are shown in Table D.3.4. The markers represent the values for the district capitals.

Table 4.44: 5km Impactor ejecta blanket deposition vulnerability and respective causalities for the district capitals' municipalities

		best		expected		worst	
Municipality	D [km]	$V_e \times 10^8$	C_e	$V_e \times 10^{10}$	C_e	$V_e \times 10^{13}$	C_e
Aveiro	715.2	3.064	0	4.092	0	2.470	0
Beja	807.1	2.776	0	3.224	0	1.246	0
Braga	751.6	2.930	0	3.671	0	1.809	0
Bragança	892.5	2.617	0	2.797	0	0.828	0
Castelo Branco	809.2	2.771	0	3.210	0	1.230	0
Coimbra	730.5	3.004	0	3.899	0	2.151	0
Évora	789.7	2.819	0	3.345	0	1.385	0
Faro	837.9	2.710	0	3.042	0	1.055	0
Funchal	776.6	2.854	0	3.446	0	1.509	0
Guarda	830.1	2.726	0	3.085	0	1.097	0
Leiria	697.2	3.144	0	4.355	0	2.953	0
Lisboa	681.3	3.224	0	4.626	0	3.513	0
Ponta Delgada	784.5	2.832	0	3.384	0	1.432	0
Portalegre	818.0	2.751	0	3.155	0	1.171	0
Porto	726.5	3.019	0	3.947	0	2.227	0
Santarém	711.4	3.080	0	4.144	0	2.562	0
Setúbal	705.3	3.107	0	4.231	0	2.719	0
Viana do Castelo	722.5	3.034	0	3.997	0	2.309	0
Vila Real	800.9	2.791	0	3.266	0	1.293	0
Viseu	777.1	2.852	0	3.443	0	1.504	0

municipalities, the data used in the plot can be found in Table D.3.4.

Once again, the case scenario terminology loses its meaning as the best-case entails the higher results and the worst-case the lowest results, and not the other way around. Despite the millimetre ejecta blanket deposit, shown in Section 4.3.5, the locations experienced, the load produce is not powerful enough to collapse even if assuming the most fragile buildings. This is of course reinforced by analysing the Figure 3.4 which suggests that the ejecta vulnerability model validity range lies in the centimetre range, *i.e.,* from 1 centimetre to 10 centimetres.

4.3.8.5 Tsunami

To complete the 5km Impactor vulnerability assessment, the vulnerabilities due to the generated tsunami wave were calculated. The tsunami vulnerabilities V_{tsu} and casualties C_{tsu}, besides also being divided in case-scenarios, are divided according to the amplitude attenuation method used. In Table 4.45 for Rump's amplitude attenuation method, and Table 4.46 for Collins' amplitude attenuation method, the vulnerabilities and casualties are displayed for the district capitals. The data for all the studies municipalities can be found in Table D.3.5 and are represented visually in Figures 4.49 and 4.50. The vulnerabilities are a direct function of the municipality local run-up. The local run-up for best-case scenario is the difference between the minimum run-up wave height and the minimum altitude. For the expected scenario, the local run-up is the difference between the minimum and maximum run-up average and the minimum altitude. Lastly, for the worst-case scenario, the local run-up height is the difference between the maximum run-up wave height and the minimum altitude.

Table 4.45: 5km Impactor tsunami vulnerability and respective causalities, for Rumpf rim-wave method

		best		expected		worst	
Municipality	D $[km]$	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
Aveiro	715.2	1.000	77916	1.000	77915	1.000	77915
Beja	807.1	0.862	28909	0.987	33128	0.997	33449
Braga	751.6	1.000	181918	1.000	181918	1.000	181918
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.000	0	0.000	0	0.000	0
Coimbra	730.5	1.000	133722	1.000	133723	1.000	133723
Évora	789.7	0.000	0	0.000	0	0.000	0
Faro	837.9	1.000	60974	1.000	60974	1.000	60974
Funchal	776.6	1.000	104129	1.000	104129	1.000	104129
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	1.000	124857	1.000	124857	1.000	124857
Lisboa	681.3	1.000	507220	1.000	507220	1.000	507220
Ponta Delgada	784.5	1.000	67864	1.000	67864	1.000	67864
Portalegre	818.0	0.000	0	0.000	0	0.000	0
Porto	726.5	1.000	215283	1.000	215283	1.000	215283
Santarém	711.4	1.000	57397	1.000	57397	1.000	57397
Setúbal	705.3	1.000	115758	1.000	115758	1.000	115758
Viana do Castelo	722.5	1.000	84636	1.000	84636	1.000	84636
Vila Real	800.9	0.000	0	0.000	0	0.000	0
Viseu	777.1	0.000	0	0.000	0	0.000	0

Table 4.46: 5km Impactor tsunami vulnerability and respective causalities, for Collins rim-wave method

		best		expected		worst	
Municipality	D $[km]$	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
Aveiro	715.2	1.000	77916	1.000	77915	1.000	77915
Beja	807.1	0.958	32124	0.996	33427	0.999	33518
Braga	751.6	1.000	181918	1.000	181918	1.000	181918
Bragança	892.5	0.000	0	0.000	0	0.000	0
Castelo Branco	809.2	0.000	0	0.000	0	0.000	0
Coimbra	730.5	1.000	133722	1.000	133723	1.000	133723
Évora	789.7	0.000	0	0.000	0	0.000	0
Faro	837.9	1.000	60974	1.000	60974	1.000	60974
Funchal	776.6	1.000	104129	1.000	104129	1.000	104129
Guarda	830.1	0.000	0	0.000	0	0.000	0
Leiria	697.2	1.000	124857	1.000	124857	1.000	124857
Lisboa	681.3	1.000	507220	1.000	507220	1.000	507220
Ponta Delgada	784.5	1.000	67864	1.000	67864	1.000	67864
Portalegre	818.0	0.000	0	0.000	0	0.000	0
Porto	726.5	1.000	215283	1.000	215283	1.000	215283
Santarém	711.4	1.000	57397	1.000	57397	1.000	57397
Setúbal	705.3	1.000	115758	1.000	115758	1.000	115758
Viana do Castelo	722.5	1.000	84636	1.000	84636	1.000	84636
Vila Real	800.9	0.000	0	0.000	0	0.000	0
Viseu	777.1	0.000	0	0.000	0	0.000	0

Both methods are equally valid, and the results produced were very similar. Analysing either the tables or the figures there is clearly a binary tendency for the vulnerability results. It seems that the vulnerability is either zero or one. This almost binary distribution can be explained by the large run-up waves the methods estimate and the Portuguese municipalities' elevation. It seems that either the run-up wave is big enough to reach a given municipality and totally wreak havoc or the wave cannot reach the municipality due to its great elevation.

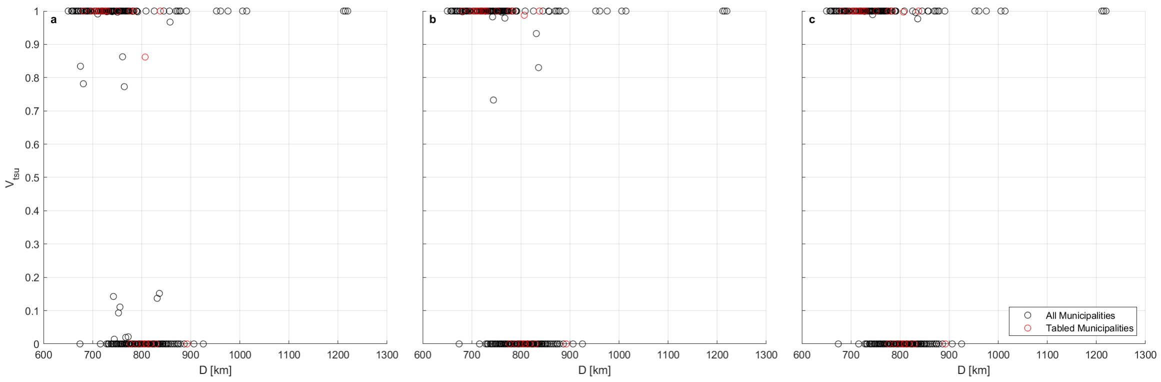

Figure 4.49: 5km Impactor tsunami vulnerability best (a), expected (b) and worst case-scenario (c) as a function of the municipalities distance. The complete data is displayed in Table D.3.5. The red markers represent the values for the district capitals.

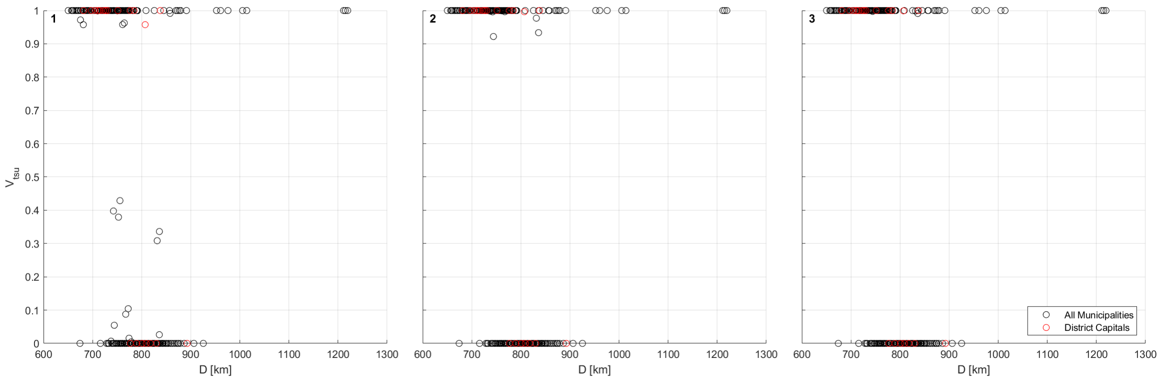

Figure 4.50: 5km Impactor rim wave vulnerability best (a), expected (b) and worst case-scenario (c) as a function of the municipalities distance. The complete data is displayed in Table D.3.5. The red markers represent the values for the district capitals.

4.3.9 Timeline

In Lisbon, the effects experienced due to the 5km Impactor are unprecedented. Lisbon experiences thermal radiation, shock waves, seismic waves, and tsunami waves. The only effect not felt in the capital is the deposition of ejected material mainly due nature of the impact and the great distance between Lisbon and the impact site. Figure 4.51 is a visual representation of the timeline of events. At the zero seconds mark occurs the 5km Impactor's collision and subsequent crater formation, 4 seconds after impact the thermal radiation reaches its peak intensity of $0.5\ MJ/m^2$ and lasts for 19 minutes. Still during the irradiation, the seismic waves hit 2 minutes and 16 seconds after impact with a Ritcher magnitude of 4.2. The next impact effect felt is the air blast. A shock wave of $37.6\ kPa$ hits Lisbon 33 minutes after the impact. The last effect that reaches Lisbon is the rim-wave with a run-up of $185\ m$ that hits the coast 49 minutes and 21 seconds after impact.

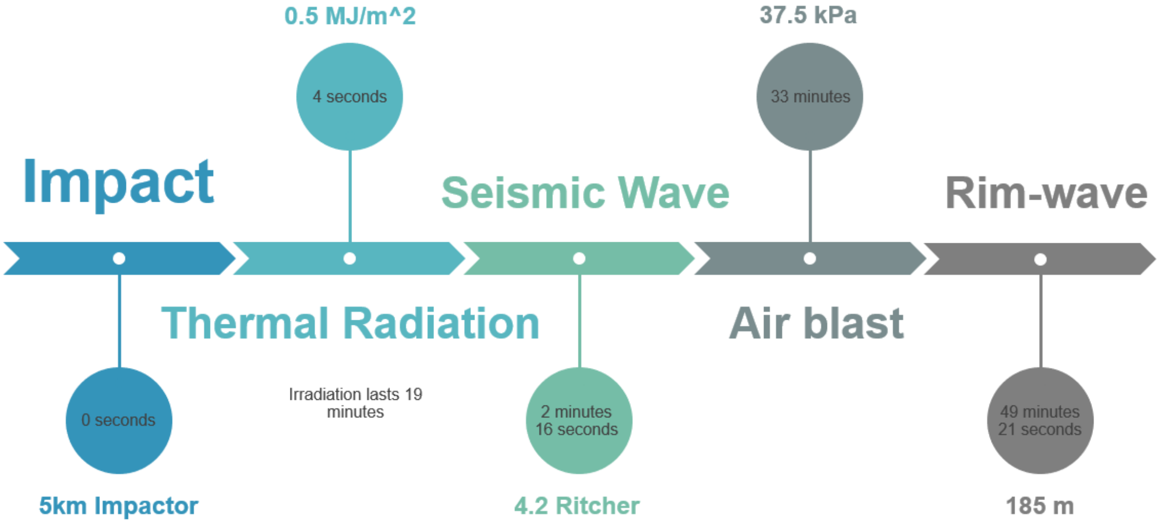

Figure 4.51: 5km Impactor impact effects' timeline experienced in the capital of Portugal.

4.4 Overview

This final section exposes all results shown during the chapter side-by-side. This allows for an easier comparison and clearer understanding of the overall results. In Table the three asteroids are compared. The impact properties, physical properties and immediate effects are shown, as well as the impact effects and casualties for the Lisbon municipality. The casualties C are represented by two values separated by a slash. The values are the minimum and maximum casualties for any impact and vulnerability model.

Table 4.47: Asteroids' physical properties, impact effects and casualties comparison for the Lisbon municipality

			Medium Asteroid	Apophis	5km Impactor
	L	$[m]$	204	370	5000
	ρ	$[kg/m^3]$	3100	3200	2500
surface	v_i	$[m/s]$	10840	12620	15000
	D_{fr}	$[km]$	5.06	8.71	88.8
	d_{fr}	$[m]$	1.08×10^3	1.85×10^3	9.08
	E	$[J]$	8.10×10^{17}	6.76×10^{18}	1.84×10^{22}
seafloor	v_i	$[m/s]$	0.0058	5.63	7220
	D_{fr}	$[m]$	5.51	183	3.00×10^4
	d_{fr}	$[m]$	1.17	39.0	6.38×10^3
	E	$[J]$	2.30×10^5	1.34×10^{12}	4.27×10^{21}
	M	$[\,]$	-2.3	2.3	8.6
	R_f	$[km]$	1.86	3.78	52.8
	M_{eff}	$[\,]$	-6.7	-2.2	4.2
	L_e	$[m]$	1.7×10^{-7}	6.3×10^{-6}	1.2×10^{-3}
	t_e	$[m]$	1.1×10^{-17}	1.3×10^{-11}	9.3×10^{-3}
	P_D	$[Pa]$	473	993	3.76×10^4
	ϕ^+	$[J/m^2]$	0	0	1.25×10^7
	ϕ^-	$[J/m^2]$	0	0	1.27×10^5
	U_{max}	$[m]$	5.8	13	237
	U_{min}	$[m]$	0.07	0.3	173
	C_{seis}	$[\,]$	0/0	0/0	0/6
	C_e	$[\,]$	0/0	0/0	0/0
	C_p	$[\,]$	11/22	11/22	29/64
	C_ϕ	$[\,]$	0/0	0/0	4049/507220
	C_{tsu}	$[\,]$	2151/105547	951/51988	507219/507220

The following tables will compare the impact effects and casualties between the district capitals for a given asteroid. The U_{min} and maximum U_{max} run-up wave height represented in the tables are local run-ups, *i.e.,* the location elevation is already being taken into consideration, and are the absolute minimum and maximum run-ups independent of the type of wave. For the casualties display a similar process was undertaken. The casualties for the best and worst-case scenario are separated by a slash. This means that these binary values are the absolute minimum and maximum casualties values experienced for a particular effect by a particular location. If, on the other hand, the casualties' value is a single integer means that both best and worst provided the same value. This could only happen if either vulnerability is zero or is one. Table 4.48 entails the Apophis results, Table 4.49 represents the Medium Asteroid's case and, finally, in Table 4.50 are shown the 5km Impactor scenario results.

Table 4.48: Apophis' impact effects and casualties experienced in the district capitals

	M_{eff}	L_e $[\mu m]$	t_e $[pm]$	P_D $[Pa]$	ϕ^- $[J/m^2]$	ϕ^+ $[J/m^2]$	U_{min} $[m]$	U_{max} $[m]$	C_{seis}	C_e	C_p	C_ϕ	C_{tsu}
Aveiro	−2.6	5.6	11	943	0	0	0.19	6.62	0	0	1/3	0	347/19719
Beja	−2.7	4.0	7.8	829	0	0	0.00	0.00	0	0	0/1	0	0
Braga	−2.6	4.9	9.7	894	0	0	0.00	0.00	0	0	4/8	0	0
Bragança	−2.7	3.1	5.8	745	0	0	0.00	0.00	0	0	0/1	0	0
Castelo Branco	−2.7	4.0	7.7	827	0	0	0.00	0.00	0	0	1/2	0	0
Coimbra	−2.6	5.3	11	922	0	0	0.00	0.00	0	0	3/5	0	0
Évora	−2.6	4.3	8.3	849	0	0	0.00	0.00	0	0	1/2	0	0
Faro	−2.7	3.7	7.0	797	0	0	0.15	8.55	0	0	1/2	0	267/23153
Funchal	−2.6	4.5	8.8	864	0	0	2.47	295	0	0	2/4	0	1293/104129
Guarda	−2.7	3.8	7.2	805	0	0	0.00	0.00	0	0	0/1	0	0
Leiria	−2.3	6.0	12	969	0	0	0.20	9.25	0	0	2/5	0	559/53876
Lisboa	−2.2	6.3	13	993	0	0	0.32	13.1	0	0	11/22	0	2408/359744
Ponta Delgada	−2.6	4.4	8.5	854	0	0	0.55	41.9	0	0	1/3	0	356/67859
Portalegre	−2.7	3.9	7.5	817	0	0	0.00	0.00	0	0	0/0	0	0
Porto	−2.6	5.3	11	927	0	0	0.17	6.42	0	0	5/9	0	951/51988
Santarém	−2.6	5.7	11	949	0	0	0.00	1.12	0	0	1/2	0	0
Setúbal	−2.6	5.8	12	957	0	0	0.32	16.8	0	0	2/5	0	548/102347
Viana do Castelo	−2.6	5.4	11	933	0	0	0.26	17.2	0	0	1/3	0	389/75899
Vila Real	−2.6	4.1	8.0	836	0	0	0.00	0.00	0	0	1/2	0	0
Viseu	−2.6	4.5	8.8	863	0	0	0.00	0.00	0	0	2/4	0	0

Table 4.49: Medium Asteroid's impact effects and casualties experienced in the district capitals

	M_{eff}	L_e $[\mu m]$	t_e $[am]$	P_D $[Pa]$	ϕ^- $[J/m^2]$	ϕ^+ $[J/m^2]$	U_{min} $[m]$	U_{max} $[m]$	C_{seis}	C_e	C_p	C_ϕ	C_{tsu}
Aveiro	−7.1	0.2	9.2	450	0	0	0.044	2.94	0	0	1/3	0	325/7687
Beja	−7.2	0.1	6.4	397	0	0	0.000	0.00	0	0	0/1	0	0
Braga	−7.1	0.1	8.0	427	0	0	0.000	0.00	0	0	4/7	0	0
Bragança	−7.3	0.1	4.7	358	0	0	0.000	0.00	0	0	0/1	0	0
Castelo Branco	−7.2	0.1	6.4	396	0	0	0.000	0.00	0	0	1/2	0	0
Coimbra	−7.1	0.1	8.7	440	0	0	0.000	0.00	0	0	3/5	0	0
Évora	−7.2	0.1	6.9	406	0	0	0.000	0.00	0	0	1/2	0	0
Faro	−7.2	0.1	5.7	382	0	0	0.035	3.79	0	0	1/2	0	253/7596
Funchal	−7.2	0.1	7.2	413	0	0	0.564	131	0	0	2/4	0	550/104129
Guarda	−7.2	0.1	5.9	386	0	0	0.000	0.00	0	0	0/1	0	0
Leiria	−6.8	0.2	10	462	0	0	0.045	4.10	0	0	2/5	0	522/16900
Lisboa	−6.7	0.2	11	473	0	0	0.075	5.79	0	0	11/22	0	2151/105547
Ponta Delgada	−7.2	0.1	7.0	409	0	0	0.126	18.6	0	0	1/2	0	294/63097
Portalegre	−7.2	0.1	6.2	392	0	0	0.000	0.00	0	0	0/0	0	0
Porto	−7.1	0.1	8.8	443	0	0	0.038	2.85	0	0	5/9	0	898/20717
Santarém	−7.1	0.2	9.4	452	0	0	0.000	0.00	0	0	1/2	0	0
Setúbal	−7.1	0.2	9.6	456	0	0	0.073	7.44	0	0	2/5	0	490/35136
Viana do Castelo	−7.1	0.1	9.0	445	0	0	0.059	7.63	0	0	1/3	0	356/26730
Vila Real	−7.2	0.1	6.6	400	0	0	0.000	0.00	0	0	1/2	0	0
Viseu	−7.2	0.1	7.2	413	0	0	0.000	0.00	0	0	2/4	0	0

Table 4.50: 5km asteroid impact effects and casualties experienced in the district capitals

	M_{eff}	L_e $[mm]$	t_e $[mm]$	P_D $[kPa]$	ϕ^- $[kJ/m^2]$	ϕ^+ $[MJ/m^2]$	U_{min} $[m]$	U_{max} $[m]$	C_{seis}	C_e	C_p	C_ϕ	C_{tsu}
Aveiro	3.8	1.1	8.1	34.4	78.2	7.8	102.5	120.3	0	0	4/9	481/77916	77915/77916
Beja	3.7	0.8	5.6	27.7	3.3	0.3	16.2	32.8	0	0	1/3	137/3114	28909/33518
Braga	3.8	0.9	6.9	31.5	39.4	3.9	52.3	110.6	0	0	8/19	908/181918	181918
Bragança	3.6	0.6	4.1	23.2	0.0	0.0	0.0	0.0	0	0	1/2	0	0
Castelo Branco	3.7	0.8	5.6	27.5	2.5	0.3	0.0	0.0	0	0	2/4	212/3285	0
Coimbra	3.8	1.0	7.6	33.1	60.5	6.0	37.9	71.5	0	0	6/14	750/133723	133722/133723
Évora	3.7	0.8	6.0	28.8	11.3	1.1	0.0	0.0	0	0	2/5	224/47507	0
Faro	3.7	0.7	5.0	25.9	0.0	0.0	96.1	155.3	0	0	2/5	0	60974
Funchal	3.7	0.9	6.3	29.6	19.4	1.9	1533.5	5364.7	0	0	4/10	465/104015	104129
Guarda	3.7	0.7	5.1	26.3	0.0	0.0	0.0	0.0	0	0	1/3	0	0
Leiria	4.1	1.1	8.7	36.1	101.7	10.2	103.9	168.1	0/1	0	6/15	878/124857	124857
Lisboa	4.2	1.2	9.3	37.6	125.0	12.5	172.7	237.2	0/6	0	29/64	4049/507220	507220
Ponta Delgada	3.7	0.8	6.1	29.1	14.3	1.4	340.2	760.6	0	0	3/6	295/66577	67864
Portalegre	3.7	0.7	5.4	27.0	0.3	0.0	0.0	0.0	0	0	0/2	90/425	0
Porto	3.8	1.0	7.7	33.5	64.9	6.5	91.2	116.6	0	0	11/24	1237/215283	215283
Santarém	3.8	1.1	8.2	34.8	82.9	8.3	39.3	71.9	0	0	3/6	364/57398	57397
Setúbal	3.8	1.1	8.4	35.3	90.7	9.1	175.3	304.8	0	0	6/13	766/115758	115758
Viana do Castelo	3.8	1.0	7.8	33.8	69.5	6.9	144.1	312.5	0	0	4/9	498/84635	84636
Vila Real	3.7	0.8	5.7	28.1	5.7	0.6	0.0	0.0	0	0	2/4	206/14538	0
Viseu	3.7	0.9	6.3	29.6	19.1	1.9	0.0	0.0	0	0	4/9	433/96864	0

Chapter 5

Conclusion and Future Work

The current dissertation studied the short-term effects of an oceanic asteroid impact on the Portuguese territory. Three different impacts were simulated for three different sized asteroids, while the impact location and angle remained unchanged. The asteroids varied not only in size, but in velocity and density. In addition to the impact effect assessment of each municipality, the vulnerabilities and the correspondent casualties were assessed for each municipality and each impact effect independently.

An extensive literature review uncovered not only the global threat of an asteroid impact, but also its equally distributed probability, substantiating the impact scenarios simulated in the present work. The literature also identified the algorithms for the principal asteroid impact processes along with establishing the principal processes that might affect people, infrastructures, and landscapes.

Multiple analytical impact effects models, based on empirical data, were utilized to assess the impact effects on locations of interest [15][16][23]. Each Portuguese municipality was assessed independently, disregarding terrain orography, and simplified into a single point at an average distance $D = 775\ km$ from the impact site.

The three separate impact simulations differ in asteroid diameter. The first simulation assumes the impact of the Apophis asteroid, a well-known and studied asteroid with a 370-metre diameter. The second simulation's asteroid, named Medium Asteroid, has a 204-metre diameter which is the average celestial object size in a near-Earth orbit. The third and last simulation was one of apocalyptic proportions. The asteroid, labelled 5km Impactor, is a massive five-kilometre-wide object.

The impact effects assessment includes a seismic shaking event, a shock wave, thermal radiation, ejecta deposit, tsunami waves, and the global effects on the planet. The seismic shock can be neglected in the Apophis' and Medium Asteroid's case and originates an 8.6 earthquake on the Ritcher scale for the 5km Impactor simulation. The average pressure difference experienced in the Portuguese territory due to the three different simulations' shock wave can cause massive structure damage and some potential casualties, however it is not at all the biggest threat. Thermal radiation is a devastating effect near the impact location but has a small reach. The impact induced fireball originates the thermal radiation experienced by the population. In the Apophis' and the Medium Asteroid's case the studied locations are shielded from direct impact and the thermal radiation is not experienced. However, in the 5km Impactor's case, the fireball is big enough to endanger some municipalities, causing thousands of casualties. The collapse of infrastructures due to ejecta deposit is the lowest impact threat of an oceanic impact. The benthic final crater formation plus the great distance between the populations and the impact site prevents the deposit of ejected material in populated areas. The literature mentions the potential tsunami threat of an oceanic impact in the form of two distinct waves, rim wave and collapse wave [17]. In the literature there is also a distinction in oceanic impacts. Deep-water impacts occur when the ocean depth is twice the impactor's diameter whist the remaining impacts are considered shallow water impacts. With this definition, the 5km Impactor collision is a shallow water impact and the Apophis' and Medium Asteroid's collision are deep-water impacts. In deep-water impacts there is a formation of both types of waves, rim-waves and collapse waves; while in shallow water impacts there is only the formation of the rim-wave. The literature states that in deep-water impacts the collapse wave is the dominant wave and the biggest concern. This statement conflicts with the present work results, as the main wave threat is, for all three impacts, the rim-wave. To complete the impact effects assessment, the possible global effects on Earth were considered. This included a possible change in orbit, in rotation period, in tilt of axis, in lost mass, and the variation in the length of a day. For all three impacts, these implications can be neglected, as there is not a significant change in any of them.

The vulnerability was assessed through pre-established vulnerability models for all the impact effects studied. All the models have subdivided in three case scenarios: best, expected, and worst. Besides the three vulnerability values for each impact, the thermal radiation vulnerability was assessed for two different radiation limits, a lower radiation limit and a higher radiation limit, totalling six different thermal radiation vulnerability values. For the rim-wave vulnerability assessment two methods from two authors [16][23] were considered, giving two sets of rim-wave values, and totalling six tsunami vulnerability values for each municipality, excluding the collapse wave. To estimate the vulnerability values for every municipality, each model needed a specific variable input. The seismic shaking vulnerability was estimated with the effective magnitude M_{eff}, the overpressure vulnerability assessment was estimated with the pressure p_D experienced at a distance D from the impact site, the thermal radiation vulnerability was estimated with the lower ϕ^- and higher thermal radiation limits ϕ^+, the ejecta blanket deposition vulnerability was assessed through the ejecta blanket load p_e and the tsunami vulnerability was estimated with the wave local run-up U_l. All the vulnerability models have a range of input values near zero and near one where the terminology (best, expected, and worst) loses its meaning and the validity of the models, in these ranges, can be questioned.

The final estimation was the casualties of every municipality for every impact effect. Rumpf *et al.* in [20] established the correlation between asteroid impact risk and population density. As such, the casualties were assessed with a simple product relation between the vulnerability and the population. For every vulnerability value, a casualty's value counterpart was estimated given the population of the specific location. The casualties were assessed independently for every municipality. The total casualties on a given municipality due to all impact effects was not estimated.

For the Apophis and the Medium Asteroid impact simulation, the impact effect with the highest vulnerability was the rim-wave, which will entail the highest casualties. There are several municipalities, mainly coastal continental regions, or island's territory, that have a vulnerability of one, meaning the entire population is endangered and perishes from the impact effect. On the other hand, there are also plenty of municipalities which have a zero vulnerability, its high altitude prevents the wave to reach their locations. The rim-wave is the most dangerous impact effect in average, *i.e.* considering all studied municipalities, however when comparing threat level of individual municipalities, the predominant effect can vary. For example, for Vila Real, as the tsunami wave cannot reach the municipality, the highest vulnerability impact effect experienced is the overpressure. For these two impact scenarios, the thermal radiation, the seismic shaking, and the ejecta deposit can be disregarded.

In the 5km Impactor simulation, the most hazardous impact effect, with the highest average vulnerability values, is the rim-wave as in the previous impact case scenarios. The rim-wave vulnerability has an almost binary distribution when compared to other impact vulnerabilities. A given municipality either has a zero vulnerability or has a vulnerability of one, or a value really close to one. As expected of the rim-wave, has it entails the highest vulnerability values it also entails the highest casualties' numbers. In the case of the 5km Impactor, and in contrary of the Apophis' and Medium Asteroid's impact, the thermal radiation also causes fatalities in the thousands range. The impact effects that can be disregarded, in terms of threat, are the ejecta deposit and the seismic shaking. Even though the impact estimates a shaking of 8.6 in the Ritcher scale, the effective magnitude drops by approximately half, which is enough to be felt, but not enough to cause any real threat.

In an asteroid ocean impact case study this far from coastal regions, the ejecta deposit and seismic shaking can be disregarded. The thermal radiation can only be disregarded for smaller asteroids and impacts on a smaller scale. The tsunami waves are assumed to be the biggest threat in an asteroid impact on the ocean, especially the rim-wave. The overpressure shock will also be, for the most part, experienced even if not on the same devastation level as the tsunami. These overall conclusion about the impact effects agree with the pre-established literature [26].

Future investigations either theoretical or experimental could improve our knowledge of asteroids impacts and better prepare the society to deal with such threats. It could be interesting to study an asteroid impact considering the land orography, the ocean bathymetry, the atmospheric passage, the atmospheric reflection, the coast wave reflection, and compare with the present work results and verify the conclusions made. To complement the current work, impacts in shallow water and in land, as well as atmospheric airbursts, could be studied. In a more empirical nature, a practical work could be made to simulate the current results.

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Appendix A

Qualitative Impact Effects' Damage Tables

In this appendix are shown tables of the qualitative damages some impact effects cause, seismic shaking, air blasts and thermal radiation. This can be useful to assess the potential consequence of a particular effect independently of the total casualties caused.

A.1 Seismic Shock

In this section the potential damage caused by seismic shaking is presented in qualitative terms. To estimate the extent of devastation from any given seismic shaking event an intensity scale is nedeed. The most widely-used scale is the Modified Mercalli Intensity Scale. The correlation between the Ritcher magnitude scale and the Modified Mercalli Intensity Scale is depicted via Table A.1.1. In Table A.1.2 is presented an abbreviated version of the Modified Mercalli Intensity scale.

Table A.1.1: Correlation between the Ritcher magnitude scale and the Modified Mercalli Intensity Scale [15]

Ritcher Magnitude	Modified Mercalli Intensity
0-1	-
1-2	I
2-3	I-II
3-4	III-IV
4-5	IV-V
5-6	VI-VII
6-7	VII-VIII
7-8	IX-X
8-9	X-XI
9+	XII

Table A.1.2: Abbreviated version of the Modified Mercalli Intensity scale [15]

Intensity	Description
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned.
IX	General panic. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.
X	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, and embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	As X. Rails bent greatly. Underground pipelines completely out of service.
XII	As X. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

A.2 Thermal Radiation

The thermal radiation required to ignite certain materials is shown in Table A.2.1. The tabled thermal exposure is a function of the impact energy and as such will vary depending on the impacting asteroid. For the first two asteroid impact scenarios, Apophis and Medium Asteroid, the fireball was entirely below the horizon which yielded no thermal radiation in any studied location. This absence is disregarding the atmospheric reflection of any radiation, among the other already mentioned simplifications. Therefore, tabling the thermal exposure limits to ignite materials for the first two scenarios would be superfluous. The table is only valid for the 5km Impactor case-scenario as the values presented depend on the impact kinetic energy released.

Table A.2.1: Ignition factor for various materials for the 5km asteroid impact-resultant thermal radiation. Modified from [15]

Material	Thermal exposure required to ignite material $[MJ/m^2]$
Clothing	13
Plywood	8.6
Grass	4.9
Newspaper	4.2
Deciduous trees	3.2
Third degree burns	5.4
Second degree burns	3.2
First degree burns	1.7

A.3 Air Blast

In this section the air blast qualitative damages are presented through Table A.3.1.

Table A.3.1: Air blast damage. Modified from [15]

p_D $[kPa]$	Description of air blast-induced damage
426	Cars and trucks will be largely displaced and grossly distorted and will require rebuilding before use.
379	Highway girder bridges will collapse.
297	Cars and trucks will be overturned and displaced, requiring major repairs.
273	Multistory steel-framed office-type buildings will suffer extreme frame distortion, incipient collapse.
121	Highway truss bridges will collapse.
100	Highway truss bridges will suffer substantial distortion of bracing.
42.6	Multistory wall-bearing buildings will collapse.
38.5	Multistory wall-bearing buildings will experience severe cracking and interior partitions will be blown down.
26.8	Wood frame buildings will almost completely collapse.
22.9	Interior partitions of wood frame buildings will be blown down. Roof will be severely damaged.
6.90	Glass windows shatter.

Appendix B

Quasi-Code

B.1 Apophis

1. Given: Earth radius ($R_\oplus$), Impact site latitude (ϕ_i), Municipality latitude (ϕ_k), Impact site longitude (λ_i), Municipality longitude (λ_k), Water density (ρ_w), Drag coefficient (C_D), Sea depth at impact site (h_{sea}), Impactor density (ρ_i), Asteroid diameter (L), Asteroid impact angle (θ), Impactor mass (m_i), Volume (V), Impactor density (ρ_i), Target density (ρ_t), Asteroid diameter (L), Impact velocity (v_i), Earth standard gravitational acceleration (g_0), Impact angle (θ), Earth radius ($R_\oplus$), Sea depth at impact site (h_{sea}), Distance between the municipality and the deep/shallow water threshold point (D_{shore}).
2. Sea floor impact velocity ($v_{i_{seafloor}}$): (2.6)
3. Impact energy (E): (2.7), (2.8), (2.9), (2.10)
4. Diameter final crater (D_{fr}): (2.11), (2.12)
5. Depth final crater (d_{fr}): (2.14), (2.16), (2.17), (2.18), (2.19)
6. Distance to the impact site (D): (2.1), (2.2), (2.3), (2.4), (2.5)
7. Effective magnitude (M_{eff}): (2.21), (2.22)
8. Overpressure (p_D): (2.24), (2.25)
9. Thermal Radiation (ϕ): (2.27), (2.28), (2.29), (2.30)
10. Ejecta fragment diameter (L_e): (2.31)
11. Ejecta blanket thickness (t_e): (2.32)
12. Rumpf rim-wave amplitude ($A(D)$): (2.37)
13. Collins rim-wave amplitude (A_{rw}): (2.38), (2.39)
14. Collapse wave amplitude (A_{cw}): (2.40), (2.41), (2.42)
15. Tsunami wave run-up (U): (2.43), (2.44)
16. Seismic shaking vulnerability (V_{seis}): (3.1)
17. Overpressure vulnerability (V_p): (3.2)
18. Thermal radiation vulnerability (V_{th}): (3.3)
19. Ejecta blanket deposition vulnerability (V_e): (3.4), (3.5)
20. Tsunami vulnerability (V_{tsu}): (3.6)

B.2 Medium Asteroid

1. Given: Earth radius ($R_\oplus$), Impact site latitude (ϕ_i), Municipality latitude (ϕ_k), Impact site longitude (λ_i), Municipality longitude (λ_k), Water density (ρ_w), Drag coefficient (C_D), Sea depth at impact site (h_{sea}), Impactor density (ρ_i), Asteroid diameter (L), As-

teroid impact angle (θ), Impactor mass (m_i), Volume (V), Impactor density (ρ_i), Target density (ρ_t), Asteroid diameter (L), Impact velocity (v_i), Earth standard gravitational acceleration (g_0), Impact angle (θ), Earth radius ($R_{♁}$), Sea depth at impact site (h_{sea}), Distance between the municipality and the deep/shallow water threshold point (D_{shore}).

2. Sea floor impact velocity ($v_{i_{seafloor}}$): (2.6)
3. Impact energy (E): (2.7), (2.8), (2.9), (2.10)
4. Diameter final crater (D_{fr}): (2.11), (2.12)
5. Depth final crater (d_{fr}): (2.14), (2.16), (2.17), (2.18), (2.19)
6. Distance to the impact site (D): (2.1), (2.2), (2.3), (2.4), (2.5)
7. Effective magnitude (M_{eff}): (2.21), (2.22)
8. Overpressure (p_D): (2.24), (2.25)
9. Thermal Radiation (ϕ): (2.27), (2.28), (2.29), (2.30)
10. Ejecta fragment diameter (L_e): (2.31)
11. Ejecta blanket thickness (t_e): (2.32)
12. Rumpf rim-wave amplitude ($A(D)$): (2.37)
13. Collins rim-wave amplitude (A_{rw}): (2.38), (2.39)
14. Collapse wave amplitude (A_{cw}): (2.40), (2.41), (2.42)
15. Tsunami wave run-up (U): (2.43), (2.44)
16. Seismic shaking vulnerability (V_{seis}): (3.1)
17. Overpressure vulnerability (V_p): (3.2)
18. Thermal radiation vulnerability (V_{th}): (3.3)
19. Ejecta blanket deposition vulnerability (V_e): (3.4), (3.5)
20. Tsunami vulnerability (V_{tsu}): (3.6)

B.3 5km Impactor

1. Given: Earth radius ($R_{♁}$), Impact site latitude (ϕ_i), Municipality latitude (ϕ_k), Impact site longitude (λ_i), Municipality longitude (λ_k), Water density (ρ_w), Drag coefficient (C_D), Sea depth at impact site (h_{sea}), Impactor density (ρ_i), Asteroid diameter (L), Asteroid impact angle (θ), Impactor mass (m_i), Volume (V), Impactor density (ρ_i), Target density (ρ_t), Asteroid diameter (L), Impact velocity (v_i), Earth standard gravitational acceleration (g_0), Impact angle (θ), Earth radius ($R_{♁}$), Sea depth at impact site (h_{sea}), Distance between the municipality and the deep/shallow water threshold point (D_{shore}).
2. Sea floor impact velocity ($v_{i_{seafloor}}$): (2.6)
3. Impact energy (E): (2.7), (2.8), (2.9), (2.10)
4. Diameter final crater (D_{fr}): (2.11), (2.13)
5. Depth final crater (d_{fr}): (2.15)
6. Distance (D): (2.1), (2.2), (2.3), (2.4), (2.5)
7. Effective magnitude (M_{eff}): (2.21), (2.22)
8. Overpressure (p_D): (2.24), (2.25)

9. Thermal Radiation (ϕ): (2.27), (2.28), (2.29), (2.30)
10. Ejecta fragment diameter (L_e): (2.31)
11. Ejecta blanket thickness (t_e): (2.32)
12. Rumpf rim-wave amplitude ($A(D)$): (2.37)
13. Collins rim-wave amplitude (A_{rw}): (2.38), (2.39)
14. Tsunami wave run-up (U): (2.43), (2.44)
15. Seismic shaking vulnerability (V_{seis}): (3.1)
16. Overpressure vulnerability (V_p): (3.2)
17. Thermal radiation vulnerability (V_{th}): (3.3)
18. Ejecta blanket deposition vulnerability (V_e): (3.4), (3.5)
19. Tsunami vulnerability (V_{tsu}): (3.6)

Appendix C

Software Code

C.1 Medium Asteroid

Below is presented the code used to determine the asteroids' average size on NASA's NEO list. The code imports from excel and averages the estimated diameter range of particular asteroids on the list. The selected asteroids were those with an approach nominal distance less than 0.05 au and with a close approach date between 10 March 2020 and 29 November 2200.

```
%% Medium Asteroid
% NASA NEO list
% Renato Morais
[velocity,neo,alldata] = xlsread('cneos_closeapproach_data.xlsx','Sheet1','E2:E9359'); %import asteroid velocity
[ndata,neo,alldata] = xlsread('cneos_closeapproach_data.xlsx','Sheet1','H2:H9359'); %import estimated diameter from nasa excel, url=https://cneos.jpl.nasa.gov/ca/
neo=string(neo); % convert cell 2 string

%divide the neo string into different strings with the max and min diameter and their respective-units
[dim(:,1) remain] = strtok(neo);
[unit(:,1) remain] = strtok(remain);
[token remain] = strtok(remain);
[dim(:,2) remain]  = strtok(remain);
unit(:,2) = strtok(remain);
dim=double(dim);

%scan the unit string to see which values are in km and convert them into m
%find the rows that correspont to asteroid to which there are no estimated diameters
n=0;
for i=1:length(neo)
    if unit(i,1) == ''
        n=n+1;
        del(n)=i;
```

```
     end
     if unit(i,1) == 'km'
         dim(i,1) = dim(i,1)*10^3;
     end
     if unit(i,2) == 'km'
         dim(i,2) = dim(i,2)*10^3;
     end
end

meddim = (dim(:,1)+dim(:,2))/2; %calculate the medium diameter for
    each
%individual asteroid

for i=1:n
     meddim(del(i)-(i-1),:)=[]; %elimite the rows which dont have a
     %estimated diameter value
end

medast=sum(meddim)/length(neo);%calculate the medium diameter in m
    from
%all the asteroids
medast=round(medast)%round the medium diameter to the nearest
    interger

medvel=sum(velocity)/length(velocity); %calculate the medium
    velocity in km/s
medvel=round(medvel,2) %round velocity to 2 decimal places
disp('Computation Completed.')
```

C.2 Impact Location

The impact location was defined as the middle point between three set of coordinates chosen to represent mainland Portugal, Madeira, and Azores. The code here presented, takes these coordinates, converts them to geocentric coordinates, computes the euclidean middle point, projects it on the Earth's surface, and converts the coordinates back into geodetic coordinates.

```
% Impact Location
% Initial set of coordinates
pt=[39.3999 -8.2245];
az=[37.7412 -25.6756];
mad=[32.7607 -16.9595];
coordenates=[pt;az;mad];
```

```

% Convertion into geocentric coordinates
[XX,YY,ZZ]=det2cen(coordenates(:,1),coordenates(:,2));

% Finding the middle point
X=sum(XX)/length(XX);
Y=sum(YY)/length(YY);
Z=sum(ZZ)/length(ZZ);

P1=[X,Y,Z] %euclidean middle point
P2=P1.*6371*10^3/norm(P1) %projected point on Earth's surface

% Convertion into geodetic coordinates
[lat2,lng2,alt2]=cen2det(P2(1),P2(2),P2(3));

MP=[lat2 lng2 alt2]%impact location geodetic coordenates

function [X,Y,Z] = det2cen(lat,lng)
a=6371*10^3;%[m]
b=a;
h=0;% Assumes the given point is on the Earth's surface
e=0;
n=a/(sqrt(1-(e^2)*(sind(lat)).^2));
X=(h+n)*cosd(lat)*cosd(lng);
Y=(h+n)*cosd(lat)*sind(lng);
Z=(h+n-e^2*n)*sind(lat);
end
function [lat,lng,alt] = cen2det(X,Y,Z)
a=6371*10^3;
b=a;
e=0;
p=(X^2+Y^2)/a^2;
q=(1-e^2)/(a^2)*Z^2;
r=(p+q-e^4)/6;
s=e^4*(p*q)/(4*r^3);
t=(1+s+sqrt(s*(2+s)))^(1/3);
u=r*(1+t+1/t);
v=sqrt(u^2+e^4*q);
w=e^2*(u+v-q)/(2*v);
k=sqrt(u+v+w^2)-w;
D=(k*sqrt(X^2+Y^2))/(k+e^2);

```

```
if (Y>=0)
   lng = 90-2*atand(X/(sqrt(X^2+Y^2)+Y)) ;
else
   lng = -90+2*atand(X/(sqrt(X^2+Y^2)-Y)) ;
end

lat=2*atand(Z/(D+sqrt(D^2+Z^2))) ;
alt=(k+e^2-1)/k*sqrt(D^2+Z^2)       ;
end

% References
% H. Vermeille, "Direct transformation from geocentric coordinates
    to geodetic coordinates.", Journal of Geodesy, Vol. 76, No. 8,
    pp. 451-454, 2002.
% H. Vermeille, "Computing geodetic coordinates from geocentric
    coordinates.", Journal of Geodesy, Vol. 78, No. 1-2, pp. 94-95,
    2004.
```

C.3 Impact Simulation

In the current section is displayed the code used to simulate the impact of the three selected asteroids. The code also includes the impact effects, the vulnerabilities and the casualties for all 308 Portuguese municipalities.

```
%% Asteroid Vulnerability Analysis
% Asteroid Ocean Impact and Portucal Short Term Case Study

% Input Data
% Computing 3 impacts simultaneously % index 1: Apophis,
                                     % index 2: Medium Asteroid,
                                     % index 3: 5km Asteroid
asteroid=["Apophis", "Medium Asteroid", "5km Impactor"];
impact_spd=[12620, 10840, 15000]; %m/s, sea lvl or land
impact_angle_deg=[45 45 45]; %degrees
density_target=2500; %kg/m3, land or sea floor
density_asteroid=[3200 3100 2500]; %kg/m3
diameter_asteroid=[370 204 5000]; %m
ocean_depth=4910; %m, obtained with google earth

% Constants
g0=9.80665; %m/s2
radius_earth=6371000; %m
drag_coef_asteroid=0.877;
```

```
density_water=1000; %kg/m3
mass_earth=5.83*10^24; %kg
earth_orbital_velocity=28780; %m/s
earth_period=24*60*60; %s

% Portugal Municipalities Database
% coordenates source: https://simplemaps.com/data/pt-cities - 09/04/2020

% population source:
% https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&contecto=pi&indOcorrCod=0008273&selTab=tab0
% - 10/04/2020
% elevation source:
% https://www.pordata.pt/Municipios/Altitude+m%c3%a1xima-50 &
% https://www.pordata.pt/Municipios/Altitude+m%c3%adnima-49 - 30/04/2020

% distance to 800m depth point source:
% https://portal.emodnet-bathymetry.eu/ \\EDMONET grid - 04/05/2020
[NUM,TXT,RAW]=xlsread('pt.xlsx','Sheet1','A2:H309');
MP=[39.6177 -16.9532]; %obtained from Impact_Location.m file
delta=acos(sind(MP(1)).*sind(NUM(:,2))+cosd(MP(1)).*cosd(NUM(:,2)).*cosd(abs(NUM(:,3)-MP(2))));
distance=delta*radius_earth;

%Establishing the tabled municipalities
j=1;
for i=1:length(distance)
    if isequal(TXT(i,1),TXT(i,2)) || isequal(TXT(i,1),{'Funchal'}) || isequal(TXT(i,1),{'Ponta Delgada'})
        capital(j)=i;
        j=j+1;
    end
end
% Direct computation from input
impact_angle_rad=impact_angle_deg.*pi/180; %rad
mass_asteroid=pi.*density_asteroid.*diameter_asteroid.^3/6; %kg, assuming a perfect sphere
impact_spd_final=impact_spd.*exp(-3.*density_water.*drag_coef_asteroid.*ocean_depth./(2.*density_asteroid.*diameter_asteroid.*sin(impact_angle_rad)));%diameter_asteroid
```

```
after atm passage
impact_energy=0.5.*mass_asteroid.*impact_spd.^2;
impact_energy_final=0.5.*mass_asteroid.*impact_spd_final.^2;


%% Crater Dimensions
diameter_trans_crater=1.161.*(density_asteroid./density_target).^(1/3).*diameter_asteroid.^0.78.*impact_spd_final.^0.44.*g0.^(-0.22).*(sin(impact_angle_rad)).^(1/3); %m
diameter_trans_crater_water=1.365.*(density_asteroid./density_water).^(1/3).*diameter_asteroid.^0.78.*impact_spd.^0.44.*g0.^(-0.22).*(sin(impact_angle_rad)).^(1/3); %m

%Ocean floor crater
depth_trans_crater=diameter_trans_crater./(2.*sqrt(2)); %m
for i=1:3
    if diameter_trans_crater(i)>25600
        crater_type(i)={'Complex'};
        diameter_final_crater(i)=1000*1.17*(diameter_trans_crater(i)/1000)^1.13/(3.2)^0.13;
        depth_final_crater=0.294*diameter_final_crater(i)^0.301;
    else
        crater_type(i)={'Simple'};
        diameter_final_crater(i)=1.25*diameter_trans_crater(i); %m
        volume_breccia_lens(i)=0.032*diameter_final_crater(i)^3; %m3
        height_rim(i)=0.07*diameter_trans_crater(i)^4/diameter_final_crater(i)^3; %m
        thickness_breccia_lens(i)=2.8*volume_breccia_lens(i)*((depth_trans_crater(i)+height_rim(i))/(depth_trans_crater(i)*diameter_final_crater(i)^2)); %m
        depth_final_crater(i)=depth_trans_crater(i)+height_rim(i)-thickness_breccia_lens(i);
    end
end
volume_trans_crater=pi.*diameter_trans_crater.^3/(16.*sqrt(2));
%water surface crater
depth_trans_crater_water=diameter_trans_crater_water./(2.*sqrt(2)); %m
for i=1:3
    if diameter_trans_crater_water(i)>25600
        crater_type_water(i)={'Complex'};
```

```
        diameter_final_crater_water(i)=1000*1.17*(diameter_trans_crater_water(i)/1000)^1.13/(3.2)^0.13;%m
        depth_final_crater_water(i)=0.294*diameter_final_crater_water(i)^0.301;
    else
        crater_type_water(i)={'Simple'};
        diameter_final_crater_water(i)=1.25*diameter_trans_crater_water(i); %m
        volume_breccia_lens_water(i)=0.032*diameter_final_crater_water(i)^3; %m3
        height_rim_water(i)=0.07*diameter_trans_crater_water(i)^4/diameter_final_crater_water(i).^3; %m
        thickness_breccia_lens_water(i)=2.8*volume_breccia_lens_water(i)*((depth_trans_crater_water(i)+height_rim_water(i))/(depth_trans_crater_water(i)*diameter_final_crater_water(i)^2)); %m
        depth_final_crater_water(i)=depth_trans_crater_water(i)+height_rim_water(i)-thickness_breccia_lens_water(i);
    end
end
volume_trans_crater_water=pi.*diameter_trans_crater_water.^3/(16.*sqrt(2));
%% Ejected Material
thickness_ejec_mat=diameter_trans_crater.^4./(112.*distance.^3); %m
velocity_ejec=sqrt(2.*g0.*radius_earth.*tan(delta)./2./(1+tan(delta)./2)); %m/s
ellipticity_trajectory_ejec=sqrt(0.5.*((velocity_ejec.^2./g0./radius_earth-1).^2+1));
semi_major_axis_trajectory=velocity_ejec.^2./2./g0./(1-ellipticity_trajectory_ejec.^2); %m
time_travel_ejec=2.*semi_major_axis_trajectory.^1.5./sqrt(g0.*radius_earth^2).*(2.*atan(sqrt((1-ellipticity_trajectory_ejec)./(1+ellipticity_trajectory_ejec)).*tan(delta./4))-(ellipticity_trajectory_ejec.*sqrt(1-ellipticity_trajectory_ejec.^2).*sin(delta./2))./(1+ellipticity_trajectory_ejec.*cos(delta./2))); %s
diameter_eject_frag=2400.*(0.0005.*diameter_final_crater).^(-1.62).*(diameter_final_crater./2./distance).^2.65; %m


%% Seismic Effects
magnitude_ritcher=0.67*log10(impact_energy_final)-5.87;
```

```
for j=1:3
    for i=1:length(distance)
        if distance(i) <60000
            magnitude_eff(i,j)=magnitude_ritcher(j)-2.38*10^-5*distance(i);
        elseif distance(i) < 700000
            magnitude_eff(i,j)=magnitude_ritcher(j)-4.8*10^-6*distance(i)-1.1644;
        else
            magnitude_eff(i,j)=magnitude_ritcher(j)-1.66*log10(delta(i))-6.399;
        end
    end
end

time_arrival_seis_waves=distance./5000; %s

%% Airblast from Impact
impact_energy_kt=impact_energy./(4.184.*10^12); %kt tnt
distance_yield_scaled=distance./impact_energy_kt.^(1/3);
pressure=75000.*290./4./distance_yield_scaled.*(1+3.*(290./distance_yield_scaled).^1.3); %Pa
time_arrival_airblast=distance./343; %s

%% Thermal Radiation
eta_high=10^-2;
eta_low=10^-4;
sigma=5.67*10^-8;

radius_fireball=0.002.*impact_energy.^(1/3);
time_reach_Tmax=radius_fireball./impact_spd;
h=(1-cos(delta)).*radius_earth;

%preallocation
dd=zeros(length(distance),3);
f=zeros(length(distance),3);
thermal_exposure_high=zeros(length(distance),3);
thermal_exposure_low=zeros(length(distance),3);
for i=1:3
    for j=1:length(distance)
        if h(j) >= radius_fireball(i)
```

```
            %disp(sprintf('The Fireball from %s is entirely below the horizon, no direct exposure.',asteroid(i)))
        else
            dd(j,i)=acos(h(j)/radius_fireball(i));
            f(j,i)=2/pi*(dd(j,i)-h(j)/radius_fireball(i)*sin(dd(j,i)));
            thermal_exposure_high(j,i)=f(j,i)*eta_high*impact_energy(i)/(2*pi*distance(j)^2);
            thermal_exposure_low(j,i)=f(j,i)*eta_low*impact_energy(i)/(2*pi*distance(j)^2);
        end
    end
end

duration_irradiation_high=eta_high.*impact_energy./(2.*pi.*radius_fireball.^2.*sigma*3000^4); %s
duration_irradiation_low=eta_low.*impact_energy./(2.*pi.*radius_fireball.^2.*sigma*3000^4); %s
ignition_high=thermal_exposure_high./10^6./(impact_energy_kt/1000).^(1/6);
ignition_low=thermal_exposure_low./10^6./(impact_energy_kt/1000).^(1/6);

%% Tsunami
% Check Coastal Regions
% j=1;
% for i=1:length(distance)
%     if NUM(i,4) == 0
%         coast(j)=i;
%         j=j+1;
%     end
% end

altitude=(NUM(:,4)+NUM(:,5))/2;
distance_shore=NUM(:,6)*1000; %m
s=abs(-800-NUM(:,4:5))./distance_shore;
for i=1:3
        amplitude(:,i)=min([0.14*diameter_trans_crater_water(i) ocean_depth]).*diameter_trans_crater_water(i)./2./(distance-distance_shore);
        amplitude_collins_rim_wave(:,i)=min([diameter_trans_crater_water(i)/14.1 ocean_depth]).*(
```

```
            diameter_trans_crater_water(i)*3/4)./(distance-distance_shore);
        amplitude_collins_collapse_wave(:,i)=0.06*min([depth_trans_crater_water(i) ocean_depth]).*((5/2*diameter_trans_crater_water(i))./(distance-distance_shore)).^(3*exp(-0.8*diameter_asteroid(i)/ocean_depth));
end
for i=1:2
    for j=1:length(distance)
        runup(j,:,i)=2.*s(j,i).*amplitude(j,:).*(amplitude(j,:)./diameter_trans_crater_water).^-0.5;
        runup_collins(j,:,i)=2.*s(j,i).*amplitude_collins_rim_wave(j,:).*(amplitude_collins_rim_wave(j,:)./diameter_trans_crater_water).^-0.5;
        runup_collapse_wave(j,:,i)=2.*s(j,i).*amplitude_collins_collapse_wave(j,:).*(amplitude_collins_collapse_wave(j,:)./diameter_trans_crater_water).^-0.5;
    end
end
% runup x: locations
%       y: asteroid
%       z: altitude min or max

for i=1:3
    for j=1:length(distance)
        if runup(j,i,2)>NUM(j,5)
            flood(j,i,1)={'Flooded'};
        elseif runup(j,i,1)>NUM(j,4) && runup(j,i,2)<NUM(j,5)
            flood(j,i,1)={'Partially flooded'};
        elseif runup(j,i,1)<NUM(j,4)
            flood(j,i,1)={'Not affected'};
        end
    end
end
for i=1:3
    for j=1:length(distance)
        if runup_collins(j,i,2)>NUM(j,5)
            flood(j,i,2)={'Flooded'};
        elseif runup_collins(j,i,1)>NUM(j,4) && runup_collins(j,i,2)<NUM(j,5)
```

```
            flood(j,i,2)={'Partially flooded'};
        elseif runup_collins(j,i,1)<NUM(j,4)
            flood(j,i,2)={'Not affected'};
        end
    end
end
for i=1:3
    for j=1:length(distance)
        if runup_collapse_wave(j,i,2)>NUM(j,5)
            flood(j,i,3)={'Flooded'};
        elseif runup_collapse_wave(j,i,1)>NUM(j,4) && runup_collapse_wave(j,i,2)<NUM(j,5)
            flood(j,i,3)={'Partially flooded'};
        elseif runup_collapse_wave(j,i,1)<NUM(j,4)
            flood(j,i,3)={'Not affected'};
        end
    end
end
% index flood (:,:,1):Rumpf rim wave
%             (:,:,2):Collins rim wave
%             (:,:,3):Collins collapse wave

amplitude_max=[”collins_rim_max”,min(diameter_trans_crater/14.1,ocean_depth);
               ”collins_colapse_max”,0.06*min(diameter_trans_crater/2.828,ocean_depth)];

for i=1:3
    for j=1:length(distance)
        for k=1:length(amplitude_max(:,1))
            time_arrival_tsu_waves_min(j,i,k)=distance(j)./min(sqrt(1.56.*diameter_trans_crater_water(i).*(1+39.5.*(double(amplitude_max(k,i+1))./diameter_trans_crater_water(i)).^2)),sqrt(9.8*ocean_depth).*(1+double(amplitude_max(k,i+1))./(2*ocean_depth)));
            time_arrival_tsu_waves_max(j,i)=distance(j)./sqrt(1.56*diameter_trans_crater_water(i)*tanh(6.28*ocean_depth/diameter_trans_crater_water(i)));
        end
    end
end
```

```

for i=1:3
    for j=1:length(distance)
        for k=1:length(amplitude_max(:,1))
            tatw(j,i,k) = time_arrival_tsu_waves_min(j,i,k)/2+
                time_arrival_tsu_waves_max(j,i)/2;
        end
    end
end
tatw=tatw/3600
time_arrival_tsu_waves_min=time_arrival_tsu_waves_min/3600
time_arrival_tsu_waves_max=time_arrival_tsu_waves_max/3600


%% Global Effects
linear_momentum_earth=mass_earth*earth_orbital_velocity; %kg m/s
linear_momentum_asteroid=mass_asteroid.*impact_spd; %kg m/s
angular_momentum_earth=5.86*10^33;
angular_momentum_asteroid=mass_asteroid.*impact_spd.*radius_earth.*
    cos(impact_angle_rad);
change_length_day=5/(4*pi*radius_earth).*mass_asteroid./mass_earth
    .*cos(impact_angle_rad).*impact_spd_final.*earth_period^2;

asteroid_earth_mass_ratio=linear_momentum_asteroid./
    linear_momentum_earth;
for i=1:3
    if asteroid_earth_mass_ratio(i) < 0.001
        global_effect_orbit(i,:)=join([”No noticeable change in
            orbit due to”,asteroid(i)]);
    elseif asteroid_earth_mass_ratio(i) <0.01
        global_effect_orbit(i,:)=join([”Noticeable change in orbit
            due to”,asteroid(i)]);
    elseif asteroid_earth_mass_ratio(i) <0.1
        global_effect_orbit(i,:)=join([”Substantial change in orbit
             due to”,asteroid(i)]);
    else
        global_effect_orbit(i,:)=join([”Totally changes orbit due
            to”,asteroid(i)]);
    end
end

```

```
asteroid_earth_angular_ratio=angular_momentum_asteroid./angular_momentum_earth;
for i=1:3
    if asteroid_earth_angular_ratio(i) < 0.001
         global_effect_period(i,:)=join(["No noticible change in rotation period and tilt of axis due to",asteroid(i)]);
    elseif asteroid_earth_mass_ratio(i) <0.01
        global_effect_period(i,:)=join(["Noticeable change in rotation period and tilt of axis due to",asteroid(i)]);
    elseif asteroid_earth_mass_ratio(i) <0.1
        global_effect_period(i,:)=join(["Substantial change in rotation period and tilt of axis due to",asteroid(i)]);
    else
        global_effect_period(i,:)=join(["Totally changes rotation period and tilt of axis due to",asteroid(i)]);
    end
end

volume_earth=4/3*pi*radius_earth^3; %m^3
crater_earth_volume_ratio=volume_trans_crater/volume_earth;
for i=1:3
    if crater_earth_volume_ratio > 0.5
        global_effect_volume(i,:)=join(["Earth is completely disrupted and loses all the mass due to",asteroid(i)]);
    elseif crater_earth_volume_ratio > 0.1
        global_effect_volume(i,:)=join(["Earth is strongly disrupted but loses a little mass due to",asteroid(i)]);
    else
        global_effect_volume(i,:)=join(["Earth is not strongly disturbed and loses negligible mass due to",asteroid(i)]);
    end
end

%% Vulnerabilities
CAS=[NUM(:,1) NUM(:,1) NUM(:,1)];
% Seismic Shaking
    % Best Case
    vulnerability_seis_best=1./(1+exp(-2.50819825.*(magnitude_eff-9.58960178)));
    % Expected Case
```

```
    vulnerability_seis_expected=1./(1+exp(-2.51607678.*(magnitude_eff-8.68559246)));
    % Worst Case
    vulnerability_seis_worst=1./(1+exp(-3.79723002.*(magnitude_eff-7.60044786)));
    % Casualties
    casualties_seis_best=floor(CAS.*vulnerability_seis_best);
    casualties_seis_expected=floor(CAS.*vulnerability_seis_expected);
    casualties_seis_worst=floor(CAS.*vulnerability_seis_worst);

% Overpressure
    % Best Case
    vulnerability_pressure_best=1./(1+exp(-0.0000189909087.*(pressure-542813.376)));
    % Expected Case
    vulnerability_pressure_expected=1./(1+exp(-0.0000242498102.*(pressure-440430.986)));
    % Worst Case
    vulnerability_pressure_worst=1./(1+exp(-0.0000284660390.*(pressure-352855.842)));
    % Casualties
    casualties_pressure_best=floor(CAS.*vulnerability_pressure_best);
    casualties_pressure_expected=floor(CAS.*vulnerability_pressure_expected);
    casualties_pressure_worst=floor(CAS.*vulnerability_pressure_worst);

% Thermal Radiation
for j=1:3
    for i=1:length(distance)
        if thermal_exposure_high(i,j) == 0
            vulnerability_thermal_high_best(i,j) = 0;
            vulnerability_thermal_high_expected(i,j) = 0;
            vulnerability_thermal_high_worst(i,j) = 0;
        else
            vulnerability_thermal_high_best(i,j)=0.25.*(1./(1+exp(-0.00000562327.*(thermal_exposure_high(i,j)-731641.664))));
            vulnerability_thermal_high_expected(i,j)=0.47.*(1./(1+exp(-0.00000562327.*(thermal_exposure_high(i,j)
```

```
-731641.664))));
            vulnerability_thermal_high_worst(i,j)=1.*(1./(1+exp(-0.00000562327.*(thermal_exposure_high(i,j)-731641.664))));
        end
        if thermal_exposure_low(i,j) == 0
            vulnerability_thermal_low_best(i,j) = 0;
            vulnerability_thermal_low_expected(i,j) = 0;
            vulnerability_thermal_low_worst(i,j) = 0;
        else
            vulnerability_thermal_low_best(i,j)=0.25.*(1./(1+exp(-0.00000562327.*(thermal_exposure_low(i,j)-731641.664))));
            vulnerability_thermal_low_expected(i,j)=0.47.*(1./(1+exp(-0.00000562327.*(thermal_exposure_low(i,j)-731641.664))));
            vulnerability_thermal_low_worst(i,j)=1.*(1./(1+exp(-0.00000562327.*(thermal_exposure_low(i,j)-731641.664))));
        end
    end
end
        % Casualties
    casualties_thermal_high_best=floor(CAS.*vulnerability_thermal_high_best);
    casualties_thermal_high_expected=floor(CAS.*vulnerability_thermal_high_expected);
    casualties_thermal_high_worst=floor(CAS.*vulnerability_thermal_high_worst);
    casualties_thermal_low_best=floor(CAS.*vulnerability_thermal_low_best);
    casualties_thermal_low_expected=floor(CAS.*vulnerability_thermal_low_expected);
    casualties_thermal_low_worst=floor(CAS.*vulnerability_thermal_low_worst);

% Ejecta Blanket Deposition
density_ejec=1600; %kg/m3
load_ejec_blanket=thickness_ejec_mat.*density_ejec.*g0/1000;%kPa
vulnerability_ejec_best=0.078.*(1+exp(-1.*(load_ejec_blanket-5.84))).^-2.58;
```

```
vulnerability_ejec_expected=0.078.*(1+exp(-1.37.*(load_ejec_blanket-3.14))).^-4.6;
vulnerability_ejec_worst=0.078.*(1+exp(-4.32.*(load_ejec_blanket-1.61))).^-4.13;
    % Casualties
    casualties_ejec_best=floor(CAS.*vulnerability_ejec_best);
    casualties_ejec_expected=floor(CAS.*vulnerability_ejec_expected);
    casualties_ejec_worst=floor(CAS.*vulnerability_ejec_worst);

% Tsunami
for j=1:3
    for i=1:length(distance)
        for k=1:length(flood(1,1,:))
            if isequal(flood(i,j,k),{'Not affected'})
                vulnerability_tsunami_best(i,j,k)=0;
                vulnerability_tsunami_expected(i,j,k)=0;
                vulnerability_tsunami_worst(i,j,k)=0;
            else
                if k==1
                    vulnerability_tsunami_best(i,j,k)=1./(1+exp(-4.528*10^-1.*((runup(i,j,1)-NUM(i,4))-1.213*10)));
                    vulnerability_tsunami_expected(i,j,k)=1./(1+exp(-3.797*10^-1.*((runup(i,j,1)+runup(i,j,2))/2-NUM(i,4)-1.114*10)));
                    vulnerability_tsunami_worst(i,j,k)=1./(1+exp(-3.067*10^-1.*((runup(i,j,2)-NUM(i,4))-1.015*10)));
                elseif k==2
                    vulnerability_tsunami_best(i,j,k)=1./(1+exp(-4.528*10^-1.*((runup_collins(i,j,1)-NUM(i,4))-1.213*10)));
                    vulnerability_tsunami_expected(i,j,k)=1./(1+exp(-3.797*10^-1.*((runup_collins(i,j,1)+runup_collins(i,j,2))/2-NUM(i,4)-1.114*10)));
                    vulnerability_tsunami_worst(i,j,k)=1./(1+exp(-3.067*10^-1.*((runup_collins(i,j,2)-NUM(i,4))-1.015*10)));

                elseif k==3
```

```
                    vulnerability_tsunami_best(i,j,k)=1./(1+exp(-4.528*10^-1.*((runup_collapse_wave(i,j,1)-NUM(i,4))-1.213*10)));
                    vulnerability_tsunami_expected(i,j,k)=1./(1+exp(-3.797*10^-1.*((runup_collapse_wave(i,j,1)+runup_collapse_wave(i,j,2))/2-NUM(i,4)-1.114*10)));
                    vulnerability_tsunami_worst(i,j,k)=1./(1+exp(-3.067*10^-1.*((runup_collapse_wave(i,j,2)-NUM(i,4))-1.015*10)));

                end
            end
        end
    end
end

    % Casualties
    casualties_tsunami_best=floor(CAS.*vulnerability_tsunami_best);
    casualties_tsunami_expected=floor(CAS.*vulnerability_tsunami_expected);
    casualties_tsunami_worst=floor(CAS.*vulnerability_tsunami_worst);

disp('Computation Completed.')
```

Appendix D

Results Tables

In this appendix are shown multiple tables for the 308 Portuguese municipalities studied. The values include the impact effects, vulnerabilities and casualties experienced in every location. The municipalities are listed alphabetically. All the values presented here were shown in Chapter 4 only for the district capitals.

D.1 Apophis' impact effects

Table D.1.1 shows Apophis' impact effects results. This encompasses the seismic shaking, the overpressure, the thermal radiation and the ejecta results. Along with the variables related to each impact effect, the distance to the impact site and the population for each municipality are shown. The municipalities are listed in alphabetic order and are associated with a ID to help concatenate ensuing tables.

Table D.1.2 shows Apophis' tsunami effects simulations. Besides the rim-wave and collapse wave variables, the minimum and maximum altitudes for each municipality are shown.

Table D.1.3 shows Apophis-induced seismic shaking and overpressure vulnerabilities and casualties for all three case scenarios.

Table D.1.4 shows Apophis-induced thermal radiation and ejecta deposit vulnerabilities and casualties for all three case scenarios.

Table D.1.5 shows Apophis-induced tsunami vulnerabilities and casualties for all three case scenarios. This table, instead of listing the municipalities, lists the ID previously associated to each municipality, for space-saving purposes.

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Abrantes	1	35377	750.5	−2.6	6.40	896	11.7	0.0	0.0	0.0	4.91	9.72
Açores	2	67864	784.5	−2.6	6.69	854	12.8	0.0	0.0	0.0	4.36	8.50
Águeda	3	45992	731.3	−2.6	6.23	921	11.1	0.0	0.0	0.0	5.26	10.50
Aguiar da Beira	4	4740	809.5	−2.7	6.90	826	13.6	0.0	0.0	0.0	4.02	7.74
Alandroal	5	5064	829.3	−2.7	7.07	806	14.3	0.0	0.0	0.0	3.77	7.20
Albergaria-a-Velha	6	24128	729.7	−2.6	6.22	923	11.0	0.0	0.0	0.0	5.29	10.57
Albufeira	7	41123	808.8	−2.7	6.89	827	13.6	0.0	0.0	0.0	4.03	7.76
Alcácer do Sal	8	11712	742.0	−2.6	6.32	907	11.4	0.0	0.0	0.0	5.06	10.05
Alcanena	9	12860	710.4	−2.6	6.05	950	10.5	0.0	0.0	0.0	5.68	11.46
Alcobaça	10	53641	683.3	−2.2	5.82	990	9.7	0.0	0.0	0.0	6.29	12.87
Alcochete	11	19505	695.2	−2.2	5.93	972	10.0	0.0	0.0	0.0	6.01	12.22
Alcoutim	12	2244	857.8	−2.7	7.31	777	15.2	0.0	0.0	0.0	3.44	6.51
Alenquer	13	43596	685.9	−2.2	5.85	986	9.8	0.0	0.0	0.0	6.23	12.73
Alfândega da Fé	14	4568	866.1	−2.7	7.38	770	15.5	0.0	0.0	0.0	3.36	6.32
Alijó	15	10703	822.5	−2.7	7.01	813	14.0	0.0	0.0	0.0	3.85	7.38
Aljezur	16	5599	753.8	−2.6	6.42	892	11.8	0.0	0.0	0.0	4.85	9.59
Aljustrel	17	8285	785.9	−2.6	6.70	853	12.8	0.0	0.0	0.0	4.34	8.46
Almada	18	168987	680.1	−2.2	5.80	995	9.6	0.0	0.0	0.0	6.37	13.05
Almeida	19	5926	862.0	−2.7	7.35	773	15.4	0.0	0.0	0.0	3.40	6.41
Almeirim	20	22569	717.4	−2.6	6.11	940	10.7	0.0	0.0	0.0	5.53	11.12
Almodôvar	21	6746	807.4	−2.7	6.88	829	13.5	0.0	0.0	0.0	4.04	7.80
Alpiarça	22	7087	719.8	−2.6	6.13	937	10.7	0.0	0.0	0.0	5.48	11.01
Alter do Chão	23	3191	799.6	−2.6	6.81	837	13.3	0.0	0.0	0.0	4.15	8.03

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Alvaiázere	24	6626	733.3	−2.6	6.25	918	11.1	0.0	0.0	0.0	5.22	10.41
Alvito	25	2462	789.4	−2.6	6.73	849	12.9	0.0	0.0	0.0	4.29	8.35
Amadora	26	181724	671.4	−2.1	5.72	1009	9.3	0.0	0.0	0.0	6.59	13.57
Amarante	27	53366	772.5	−2.6	6.58	869	12.4	0.0	0.0	0.0	4.55	8.91
Amares	28	18114	759.3	−2.6	6.47	885	12.0	0.0	0.0	0.0	4.76	9.38
Anadia	29	27298	730.8	−2.6	6.23	922	11.1	0.0	0.0	0.0	5.27	10.52
Angra do Heroísmo	30	33903	891.2	−2.7	7.60	747	16.5	0.0	0.0	0.0	3.11	5.80
Ansião	31	12106	728.5	−2.6	6.21	925	11.0	0.0	0.0	0.0	5.31	10.62
Arcos de Valdevez	32	20970	760.9	−2.6	6.49	883	12.0	0.0	0.0	0.0	4.73	9.32
Arganil	33	11068	761.6	−2.6	6.49	882	12.0	0.0	0.0	0.0	4.72	9.30
Armamar	34	5792	801.6	−2.6	6.83	835	13.3	0.0	0.0	0.0	4.12	7.97
Arouca	35	20861	752.7	−2.6	6.42	893	11.7	0.0	0.0	0.0	4.87	9.63
Arraiolos	36	6944	779.2	−2.6	6.64	861	12.6	0.0	0.0	0.0	4.44	8.68
Arronches	37	2860	832.4	−2.7	7.09	802	14.4	0.0	0.0	0.0	3.73	7.12
Arruda dos Vinhos	38	15082	681.1	−2.2	5.80	994	9.6	0.0	0.0	0.0	6.35	13.00
Aveiro	39	77916	715.2	−2.6	6.10	943	10.6	0.0	0.0	0.0	5.58	11.23
Avis	40	4249	781.5	−2.6	6.66	858	12.7	0.0	0.0	0.0	4.41	8.60
Azambuja	41	22445	697.7	−2.3	5.95	969	10.1	0.0	0.0	0.0	5.96	12.09
Baião	42	18891	774.2	−2.6	6.60	867	12.4	0.0	0.0	0.0	4.52	8.85
Barcelos	43	116531	735.5	−2.6	6.27	915	11.2	0.0	0.0	0.0	5.18	10.32
Barrancos	44	1645	878.8	−2.7	7.49	758	16.0	0.0	0.0	0.0	3.23	6.05
Barreiro	45	75419	687.7	−2.2	5.86	984	9.8	0.0	0.0	0.0	6.19	12.63
Batalha	46	15840	695.8	−2.2	5.93	971	10.0	0.0	0.0	0.0	6.00	12.19

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Beja	47	33550	807.1	−2.7	6.88	829	13.5	0.0	0.0	0.0	4.05	7.81
Belmonte	48	6407	822.0	−2.7	7.01	813	14.0	0.0	0.0	0.0	3.86	7.39
Benavente	49	30214	704.3	−2.6	6.00	959	10.3	0.0	0.0	0.0	5.81	11.76
Bombarral	50	12533	670.3	−2.1	5.71	1011	9.3	0.0	0.0	0.0	6.62	13.63
Borba	51	6790	822.9	−2.7	7.01	812	14.0	0.0	0.0	0.0	3.85	7.37
Boticas	52	5059	816.2	−2.7	6.96	819	13.8	0.0	0.0	0.0	3.93	7.55
Braga	53	181919	751.6	−2.6	6.41	894	11.7	0.0	0.0	0.0	4.89	9.67
Bragança	54	33586	892.5	−2.7	7.61	745	16.5	0.0	0.0	0.0	3.10	5.78
Cabeceiras de Basto	55	15699	785.6	−2.6	6.70	853	12.8	0.0	0.0	0.0	4.35	8.47
Cadaval	56	13627	675.3	−2.1	5.76	1003	9.5	0.0	0.0	0.0	6.49	13.34
Caldas da Rainha	57	51540	670.6	−2.1	5.72	1011	9.3	0.0	0.0	0.0	6.61	13.62
Calheta (Açores)	58	10865	767.6	−2.6	6.54	875	12.2	0.0	0.0	0.0	4.62	9.08
Calheta (Madeira)	59	3205	960.7	−2.8	8.19	690	19.1	0.0	0.0	0.0	2.55	4.63
Câmara de Lobos	60	33732	773.5	−2.6	6.59	867	12.4	0.0	0.0	0.0	4.53	8.87
Caminha	61	15873	727.9	−2.6	6.20	925	11.0	0.0	0.0	0.0	5.32	10.65
Campo Maior	62	7907	852.8	−2.7	7.27	782	15.1	0.0	0.0	0.0	3.50	6.62
Cantanhede	63	35068	716.5	−2.6	6.11	941	10.6	0.0	0.0	0.0	5.55	11.16
Carrazeda de Ansiães	64	5683	835.7	−2.7	7.12	799	14.5	0.0	0.0	0.0	3.69	7.04
Carregal do Sal	65	9290	767.6	−2.6	6.54	875	12.2	0.0	0.0	0.0	4.62	9.08
Cartaxo	66	23740	703.3	−2.6	5.99	960	10.3	0.0	0.0	0.0	5.83	11.80
Cascais	67	212474	657.1	−2.1	5.60	1033	9.0	0.0	0.0	0.0	6.98	14.48
Castanheira de Pêra	68	2650	747.7	−2.6	6.37	899	11.6	0.0	0.0	0.0	4.96	9.82
Castelo Branco	69	52192	809.2	−2.7	6.90	827	13.6	0.0	0.0	0.0	4.02	7.75

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Castelo de Paiva	70	15567	753.4	−2.6	6.42	892	11.8	0.0	0.0	0.0	4.86	9.60
Castelo de Vide	71	2951	814.8	−2.7	6.94	821	13.8	0.0	0.0	0.0	3.95	7.59
Castro Daire	72	13928	778.1	−2.6	6.63	862	12.6	0.0	0.0	0.0	4.46	8.72
Castro Marim	73	6274	869.8	−2.7	7.41	766	15.7	0.0	0.0	0.0	3.32	6.24
Castro Verde	74	6946	798.6	−2.6	6.81	839	13.2	0.0	0.0	0.0	4.16	8.06
Celorico da Beira	75	6978	820.5	−2.7	6.99	815	14.0	0.0	0.0	0.0	3.88	7.43
Celorico de Basto	76	19075	781.7	−2.6	6.66	858	12.7	0.0	0.0	0.0	4.41	8.60
Chamusca	77	9253	727.3	−2.6	6.20	926	11.0	0.0	0.0	0.0	5.33	10.67
Chaves	78	39345	833.4	−2.7	7.10	801	14.4	0.0	0.0	0.0	3.72	7.09
Cinfães	79	18470	768.0	−2.6	6.55	874	12.2	0.0	0.0	0.0	4.62	9.07
Coimbra	80	133724	730.5	−2.6	6.23	922	11.1	0.0	0.0	0.0	5.27	10.54
Condeixa-a-Nova	81	17597	723.4	−2.6	6.17	932	10.9	0.0	0.0	0.0	5.41	10.85
Constância	82	4002	739.0	−2.6	6.30	911	11.3	0.0	0.0	0.0	5.11	10.17
Coruche	83	17629	728.7	−2.6	6.21	924	11.0	0.0	0.0	0.0	5.31	10.61
Corvo	84	65	1211.3	−2.9	10.32	542	30.4	0.0	0.0	0.0	1.38	2.31
Covilhã	85	47127	808.5	−2.7	6.89	828	13.5	0.0	0.0	0.0	4.03	7.77
Crato	86	3185	799.6	−2.6	6.82	837	13.3	0.0	0.0	0.0	4.15	8.03
Cuba	87	4599	800.3	−2.6	6.82	837	13.3	0.0	0.0	0.0	4.14	8.01
Elvas	88	20706	846.6	−2.7	7.22	788	14.9	0.0	0.0	0.0	3.57	6.77
Entroncamento	89	21214	727.6	−2.6	6.20	926	11.0	0.0	0.0	0.0	5.33	10.66
Espinho	90	29484	721.2	−2.6	6.15	935	10.8	0.0	0.0	0.0	5.45	10.95
Esposende	91	34057	722.0	−2.6	6.15	934	10.8	0.0	0.0	0.0	5.44	10.91
Estarreja	92	25965	722.8	−2.6	6.16	932	10.8	0.0	0.0	0.0	5.42	10.87

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Estremoz	93	12816	811.0	−2.7	6.91	825	13.6	0.0	0.0	0.0	4.00	7.70
Évora	94	52454	789.6	−2.6	6.73	849	12.9	0.0	0.0	0.0	4.29	8.34
Fafe	95	48271	769.6	−2.6	6.56	872	12.3	0.0	0.0	0.0	4.59	9.01
Faro	96	60974	837.9	−2.7	7.14	797	14.5	0.0	0.0	0.0	3.67	6.98
Felgueiras	97	56576	765.5	−2.6	6.52	877	12.1	0.0	0.0	0.0	4.66	9.16
Ferreira do Alentejo	98	7848	791.7	−2.6	6.75	846	13.0	0.0	0.0	0.0	4.26	8.28
Ferreira do Zêzere	99	7989	741.2	−2.6	6.32	908	11.4	0.0	0.0	0.0	5.07	10.08
Figueira da Foz	100	58866	692.7	−2.2	5.90	976	9.9	0.0	0.0	0.0	6.07	12.36
Figueira de Castelo Rodrigo	101	5652	859.0	−2.7	7.32	776	15.3	0.0	0.0	0.0	3.43	6.48
Figueiró dos Vinhos	102	5608	742.2	−2.6	6.33	907	11.4	0.0	0.0	0.0	5.06	10.04
Fornos de Algodres	103	4561	807.8	−2.7	6.88	828	13.5	0.0	0.0	0.0	4.04	7.79
Freixo de Espada à Cinta	104	3312	874.7	−2.7	7.46	762	15.9	0.0	0.0	0.0	3.27	6.14
Fronteira	105	2986	802.3	−2.6	6.84	834	13.3	0.0	0.0	0.0	4.11	7.95
Fundão	106	26719	808.2	−2.7	6.89	828	13.5	0.0	0.0	0.0	4.03	7.78
Gavião	107	3347	773.2	−2.6	6.59	868	12.4	0.0	0.0	0.0	4.54	8.88
Góis	108	3825	756.6	−2.6	6.45	888	11.9	0.0	0.0	0.0	4.80	9.48
Golegã	109	5375	726.5	−2.6	6.19	927	10.9	0.0	0.0	0.0	5.35	10.71
Gondomar	110	165631	732.9	−2.6	6.25	919	11.1	0.0	0.0	0.0	5.23	10.43
Gouveia	111	12486	802.3	−2.6	6.84	834	13.3	0.0	0.0	0.0	4.11	7.95
Grândola	112	14570	742.9	−2.6	6.33	906	11.4	0.0	0.0	0.0	5.04	10.01
Guarda	113	39103	830.1	−2.7	7.08	805	14.3	0.0	0.0	0.0	3.76	7.18
Guimarães	114	152792	758.9	−2.6	6.47	885	11.9	0.0	0.0	0.0	4.77	9.39
Horta	115	14542	1014.0	−2.8	8.64	652	21.3	0.0	0.0	0.0	2.21	3.94

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Idanha-a-Nova	116	8157	830.4	-2.7	7.08	805	14.3	0.0	0.0	0.0	3.75	7.17
Ílhavo	117	38405	712.8	-2.6	6.08	947	10.5	0.0	0.0	0.0	5.63	11.34
Lagoa (Açores)	118	22748	790.3	-2.6	6.74	848	12.9	0.0	0.0	0.0	4.28	8.32
Lagoa (Faro)	119	14681	776.2	-2.6	6.62	864	12.5	0.0	0.0	0.0	4.49	8.78
Lagos	120	30442	773.8	-2.6	6.59	867	12.4	0.0	0.0	0.0	4.53	8.86
Lajes das Flores	121	1464	1219.6	-3.0	10.39	538	30.8	0.0	0.0	0.0	1.36	2.26
Lajes do Pico	122	4498	879.4	-2.7	7.50	757	16.0	0.0	0.0	0.0	3.22	6.04
Lamego	123	24959	791.6	-2.6	6.75	846	13.0	0.0	0.0	0.0	4.26	8.28
Leiria	124	124857	697.2	-2.3	5.94	969	10.1	0.0	0.0	0.0	5.97	12.12
Lisboa	125	507220	681.3	-2.2	5.81	993	9.6	0.0	0.0	0.0	6.34	12.98
Loulé	126	68873	825.7	-2.7	7.04	809	14.1	0.0	0.0	0.0	3.81	7.30
Loures	127	211359	676.1	-2.2	5.76	1002	9.5	0.0	0.0	0.0	6.47	13.29
Lourinhã	128	25670	657.1	-2.1	5.60	1033	9.0	0.0	0.0	0.0	6.98	14.47
Lousã	129	17128	744.8	-2.6	6.35	903	11.5	0.0	0.0	0.0	5.01	9.94
Lousada	130	46790	756.4	-2.6	6.45	888	11.9	0.0	0.0	0.0	4.81	9.49
Mação	131	6323	767.4	-2.6	6.54	875	12.2	0.0	0.0	0.0	4.63	9.09
Macedo de Cavaleiros	132	14550	869.9	-2.7	7.41	766	15.7	0.0	0.0	0.0	3.32	6.24
Machico	133	20094	765.8	-2.6	6.53	877	12.2	0.0	0.0	0.0	4.65	9.14
Madalena	134	5875	1005.5	-2.8	8.57	658	20.9	0.0	0.0	0.0	2.26	4.04
Madeira	135	104129	776.6	-2.6	6.62	864	12.5	0.0	0.0	0.0	4.48	8.77
Mafra	136	84008	660.5	-2.1	5.63	1027	9.0	0.0	0.0	0.0	6.89	14.25
Maia	137	137727	727.6	-2.6	6.20	926	11.0	0.0	0.0	0.0	5.33	10.66
Mangualde	138	18618	789.0	-2.6	6.72	849	12.9	0.0	0.0	0.0	4.30	8.36

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Manteigas	139	3037	806.1	-2.7	6.87	830	13.5	0.0	0.0	0.0	4.06	7.84
Marco de Canaveses	140	51661	765.3	-2.6	6.52	877	12.1	0.0	0.0	0.0	4.66	9.16
Marinha Grande	141	38404	686.3	-2.2	5.85	986	9.8	0.0	0.0	0.0	6.22	12.70
Marvão	142	3054	821.6	-2.7	7.00	814	14.0	0.0	0.0	0.0	3.86	7.40
Matosinhos	143	174382	720.8	-2.6	6.14	935	10.8	0.0	0.0	0.0	5.46	10.97
Mealhada	144	19892	729.0	-2.6	6.21	924	11.0	0.0	0.0	0.0	5.30	10.60
Mêda	145	4617	835.1	-2.7	7.12	800	14.5	0.0	0.0	0.0	3.70	7.05
Melgaço	146	8144	781.5	-2.6	6.66	858	12.7	0.0	0.0	0.0	4.41	8.61
Mértola	147	6202	836.0	-2.7	7.13	799	14.5	0.0	0.0	0.0	3.69	7.03
Mesão Frio	148	3996	787.5	-2.6	6.71	851	12.9	0.0	0.0	0.0	4.32	8.41
Mira	149	11831	705.1	-2.6	6.01	958	10.3	0.0	0.0	0.0	5.79	11.71
Miranda do Corvo	150	12687	737.5	-2.6	6.29	913	11.3	0.0	0.0	0.0	5.14	10.24
Miranda do Douro	151	6877	925.5	-2.8	7.89	718	17.7	0.0	0.0	0.0	2.82	5.18
Mirandela	152	21808	850.4	-2.7	7.25	785	15.0	0.0	0.0	0.0	3.52	6.68
Mogadouro	153	8481	886.6	-2.7	7.56	751	16.3	0.0	0.0	0.0	3.16	5.89
Moimenta da Beira	154	9729	805.7	-2.7	6.87	831	13.5	0.0	0.0	0.0	4.07	7.85
Moita	155	64526	694.9	-2.2	5.92	973	10.0	0.0	0.0	0.0	6.02	12.24
Monção	156	17902	762.9	-2.6	6.50	880	12.1	0.0	0.0	0.0	4.70	9.25
Monchique	157	5182	774.2	-2.6	6.60	867	12.4	0.0	0.0	0.0	4.52	8.85
Mondim de Basto	158	6985	786.0	-2.6	6.70	853	12.8	0.0	0.0	0.0	4.34	8.46
Monforte	159	2989	820.4	-2.7	6.99	815	13.9	0.0	0.0	0.0	3.88	7.44
Montalegre	160	9090	809.8	-2.7	6.90	826	13.6	0.0	0.0	0.0	4.01	7.73
Montemor-o-Novo	161	15740	761.1	-2.6	6.49	883	12.0	0.0	0.0	0.0	4.73	9.31

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Montemor-o-Velho	162	25230	707.7	−2.6	6.03	954	10.4	0.0	0.0	0.0	5.73	11.59
Montijo	163	56887	695.1	−2.2	5.92	972	10.0	0.0	0.0	0.0	6.01	12.23
Mora	164	4188	759.9	−2.6	6.48	884	12.0	0.0	0.0	0.0	4.75	9.36
Mortágua	165	8856	747.5	−2.6	6.37	900	11.6	0.0	0.0	0.0	4.96	9.83
Moura	166	13749	838.6	−2.7	7.15	796	14.6	0.0	0.0	0.0	3.66	6.96
Mourão	167	2456	841.4	−2.7	7.17	793	14.7	0.0	0.0	0.0	3.63	6.89
Murça	168	5480	826.8	−2.7	7.05	808	14.2	0.0	0.0	0.0	3.80	7.27
Murtosa	169	10244	717.1	−2.6	6.11	940	10.7	0.0	0.0	0.0	5.54	11.14
Nazaré	170	14180	675.2	−2.1	5.75	1003	9.5	0.0	0.0	0.0	6.49	13.34
Nelas	171	13030	780.7	−2.6	6.65	859	12.6	0.0	0.0	0.0	4.42	8.63
Nisa	172	6149	797.3	−2.6	6.79	840	13.2	0.0	0.0	0.0	4.18	8.10
Nordeste	173	4875	737.6	−2.6	6.29	913	11.3	0.0	0.0	0.0	5.14	10.23
Óbidos	174	11719	669.5	−2.1	5.71	1012	9.3	0.0	0.0	0.0	6.64	13.69
Odemira	175	24621	756.2	−2.6	6.44	889	11.9	0.0	0.0	0.0	4.81	9.50
Odivelas	176	159602	675.1	−2.1	5.75	1003	9.5	0.0	0.0	0.0	6.50	13.35
Oeiras	177	176218	666.8	−2.1	5.68	1017	9.2	0.0	0.0	0.0	6.72	13.85
Oleiros	178	5045	773.0	−2.6	6.59	868	12.4	0.0	0.0	0.0	4.54	8.89
Olhão	179	44607	844.9	−2.7	7.20	790	14.8	0.0	0.0	0.0	3.59	6.81
Oliveira de Azeméis	180	66113	732.1	−2.6	6.24	920	11.1	0.0	0.0	0.0	5.24	10.46
Oliveira de Frades	181	9920	755.7	−2.6	6.44	889	11.8	0.0	0.0	0.0	4.82	9.51
Oliveira do Bairro	182	23944	726.5	−2.6	6.19	927	10.9	0.0	0.0	0.0	5.35	10.71
Oliveira do Hospital	183	19331	778.7	−2.6	6.64	861	12.6	0.0	0.0	0.0	4.45	8.70
Ourém	184	44068	715.8	−2.6	6.10	942	10.6	0.0	0.0	0.0	5.56	11.20

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Ourique	185	4653	788.5	−2.6	6.72	850	12.9	0.0	0.0	0.0	4.31	8.38
Ovar	186	54120	719.9	−2.6	6.14	936	10.7	0.0	0.0	0.0	5.48	11.01
Paços de Ferreira	187	56709	748.5	−2.6	6.38	898	11.6	0.0	0.0	0.0	4.94	9.79
Palmela	188	64214	704.4	−2.6	6.00	959	10.3	0.0	0.0	0.0	5.81	11.75
Pampilhosa da Serra	189	4052	769.8	−2.6	6.56	872	12.3	0.0	0.0	0.0	4.59	9.00
Paredes	190	86072	750.6	−2.6	6.40	896	11.7	0.0	0.0	0.0	4.91	9.71
Paredes de Coura	191	8560	751.0	−2.6	6.40	895	11.7	0.0	0.0	0.0	4.90	9.70
Pedrógão Grande	192	3429	753.2	−2.6	6.42	892	11.8	0.0	0.0	0.0	4.86	9.61
Penacova	193	13812	742.4	−2.6	6.33	906	11.4	0.0	0.0	0.0	5.05	10.03
Penafiel	194	69922	754.7	−2.6	6.43	890	11.8	0.0	0.0	0.0	4.84	9.55
Penalva do Castelo	195	7175	795.0	−2.6	6.78	843	13.1	0.0	0.0	0.0	4.21	8.17
Penamacor	196	4831	836.5	−2.7	7.13	798	14.5	0.0	0.0	0.0	3.68	7.02
Penedono	197	2610	824.4	−2.7	7.03	811	14.1	0.0	0.0	0.0	3.83	7.33
Penela	198	5439	733.0	−2.6	6.25	919	11.1	0.0	0.0	0.0	5.22	10.43
Peniche	199	26487	650.3	−2.0	5.54	1045	8.8	0.0	0.0	0.0	7.18	14.93
Peso da Régua	200	15830	794.7	−2.6	6.77	843	13.1	0.0	0.0	0.0	4.22	8.18
Pinhel	201	8607	849.0	−2.7	7.24	786	14.9	0.0	0.0	0.0	3.54	6.71
Pombal	202	51684	712.0	−2.6	6.07	948	10.5	0.0	0.0	0.0	5.64	11.38
Ponta do Sol	203	8544	770.9	−2.6	6.57	871	12.3	0.0	0.0	0.0	4.57	8.96
Ponte da Barca	204	11210	759.2	−2.6	6.47	885	11.9	0.0	0.0	0.0	4.76	9.38
Ponte de Lima	205	41499	744.6	−2.6	6.35	903	11.5	0.0	0.0	0.0	5.01	9.95
Ponte de Sôr	206	15092	768.8	−2.6	6.55	873	12.3	0.0	0.0	0.0	4.60	9.04
Portalegre	207	22359	818.0	−2.7	6.97	817	13.9	0.0	0.0	0.0	3.91	7.50

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Portel	208	5870	812.6	-2.7	6.93	823	13.7	0.0	0.0	0.0	3.98	7.65
Portimão	209	55416	783.2	-2.6	6.67	856	12.7	0.0	0.0	0.0	4.38	8.55
Porto	210	215284	726.5	-2.6	6.19	927	10.9	0.0	0.0	0.0	5.35	10.71
Porto de Mós	211	23288	696.6	-2.3	5.94	970	10.1	0.0	0.0	0.0	5.98	12.15
Porto Moniz	212	2350	750.9	-2.6	6.40	895	11.7	0.0	0.0	0.0	4.90	9.70
Porto Santo	213	5176	731.2	-2.6	6.23	921	11.1	0.0	0.0	0.0	5.26	10.50
Póvoa de Lanhoso	214	21446	764.6	-2.6	6.52	878	12.1	0.0	0.0	0.0	4.67	9.19
Póvoa de Varzim	215	62510	719.4	-2.6	6.13	937	10.7	0.0	0.0	0.0	5.49	11.03
Povoação	216	5954	748.3	-2.6	6.38	899	11.6	0.0	0.0	0.0	4.95	9.80
Proença-a-Nova	217	7390	772.5	-2.6	6.58	869	12.4	0.0	0.0	0.0	4.55	8.91
Redondo	218	6387	818.0	-2.7	6.97	817	13.9	0.0	0.0	0.0	3.91	7.50
Reguengos de Monsaraz	219	10036	824.0	-2.7	7.02	811	14.1	0.0	0.0	0.0	3.83	7.34
Resende	220	10241	778.8	-2.6	6.64	861	12.6	0.0	0.0	0.0	4.45	8.69
Ribeira Brava	221	12411	772.1	-2.6	6.58	869	12.4	0.0	0.0	0.0	4.55	8.92
Ribeira de Pena	222	6031	800.9	-2.6	6.83	836	13.3	0.0	0.0	0.0	4.13	7.99
Ribeira Grande	223	32698	768.8	-2.6	6.55	873	12.3	0.0	0.0	0.0	4.60	9.04
Rio Maior	224	20340	688.3	-2.2	5.87	983	9.8	0.0	0.0	0.0	6.17	12.59
Sabrosa	225	5917	814.0	-2.7	6.94	822	13.7	0.0	0.0	0.0	3.96	7.61
Sabugal	226	10748	843.8	-2.7	7.19	791	14.8	0.0	0.0	0.0	3.60	6.84
Salvaterra de Magos	227	21268	704.7	-2.6	6.01	958	10.3	0.0	0.0	0.0	5.80	11.73
Santa Comba Dão	228	10506	756.0	-2.6	6.44	889	11.8	0.0	0.0	0.0	4.81	9.50
Santa Cruz	229	44744	770.5	-2.6	6.57	871	12.3	0.0	0.0	0.0	4.58	8.98
Santa Cruz da Graciosa	230	4225	952.4	-2.8	8.12	696	18.8	0.0	0.0	0.0	2.61	4.75

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Santa Cruz das Flores	231	2164	1214.9	−2.9	10.35	540	30.5	0.0	0.0	0.0	1.37	2.29
Santa Maria da Feira	232	138525	727.5	−2.6	6.20	926	11.0	0.0	0.0	0.0	5.33	10.67
Santa Marta de Penaguião	233	6649	794.5	−2.6	6.77	843	13.1	0.0	0.0	0.0	4.22	8.19
Santana	234	6750	757.9	−2.6	6.46	886	11.9	0.0	0.0	0.0	4.78	9.43
Santarém	235	57398	711.4	−2.6	6.06	949	10.5	0.0	0.0	0.0	5.66	11.41
Santiago do Cacém	236	28725	737.0	−2.6	6.28	913	11.3	0.0	0.0	0.0	5.15	10.26
Santo Tirso	237	68221	741.7	−2.6	6.32	907	11.4	0.0	0.0	0.0	5.06	10.06
São Brás de Alportel	238	10416	835.9	−2.7	7.12	799	14.5	0.0	0.0	0.0	3.69	7.03
São João da Madeira	239	21761	731.1	−2.6	6.23	921	11.1	0.0	0.0	0.0	5.26	10.51
São João da Pesqueira	240	7154	826.0	−2.7	7.04	809	14.1	0.0	0.0	0.0	3.81	7.29
São Pedro do Sul	241	15488	764.6	−2.6	6.52	878	12.1	0.0	0.0	0.0	4.67	9.19
São Roque do Pico	242	3264	781.1	−2.6	6.66	859	12.6	0.0	0.0	0.0	4.42	8.62
São Vicente	243	5150	757.7	−2.6	6.46	887	11.9	0.0	0.0	0.0	4.79	9.44
Sardoal	244	3739	753.3	−2.6	6.42	892	11.8	0.0	0.0	0.0	4.86	9.61
Sátão	245	11602	792.8	−2.6	6.76	845	13.0	0.0	0.0	0.0	4.24	8.24
Seia	246	22412	791.9	−2.6	6.75	846	13.0	0.0	0.0	0.0	4.26	8.27
Seixal	247	166835	685.7	−2.2	5.84	987	9.7	0.0	0.0	0.0	6.24	12.74
Sernancelhe	248	5384	814.8	−2.7	6.94	821	13.8	0.0	0.0	0.0	3.95	7.59
Serpa	249	14374	831.6	−2.7	7.09	803	14.3	0.0	0.0	0.0	3.74	7.14
Sertã	250	14682	757.4	−2.6	6.45	887	11.9	0.0	0.0	0.0	4.79	9.45
Sesimbra	251	51559	690.4	−2.2	5.88	979	9.9	0.0	0.0	0.0	6.12	12.48
Setúbal	252	115758	705.3	−2.6	6.01	957	10.3	0.0	0.0	0.0	5.79	11.70
Sever do Vouga	253	11403	739.6	−2.6	6.30	910	11.3	0.0	0.0	0.0	5.10	10.15

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Silves	254	36174	789.2	−2.6	6.73	849	12.9	0.0	0.0	0.0	4.30	8.35
Sines	255	13631	724.3	−2.6	6.17	930	10.9	0.0	0.0	0.0	5.39	10.81
Sintra	256	388434	658.7	−2.1	5.61	1030	9.0	0.0	0.0	0.0	6.93	14.37
Sobral de Monte Agraço	257	10490	674.3	−2.1	5.75	1005	9.4	0.0	0.0	0.0	6.52	13.40
Soure	258	17277	712.4	−2.6	6.07	947	10.5	0.0	0.0	0.0	5.63	11.36
Sousel	259	4454	801.6	−2.6	6.83	835	13.3	0.0	0.0	0.0	4.12	7.97
Tábua	260	11403	764.4	−2.6	6.51	878	12.1	0.0	0.0	0.0	4.68	9.19
Tabuaço	261	6017	812.0	−2.7	6.92	824	13.7	0.0	0.0	0.0	3.98	7.67
Tarouca	262	7761	792.6	−2.6	6.76	845	13.0	0.0	0.0	0.0	4.25	8.25
Tavira	263	24750	856.6	−2.7	7.30	779	15.2	0.0	0.0	0.0	3.46	6.53
Terras de Bouro	264	6405	765.2	−2.6	6.52	878	12.1	0.0	0.0	0.0	4.66	9.17
Tomar	265	36902	731.6	−2.6	6.24	920	11.1	0.0	0.0	0.0	5.25	10.48
Tondela	266	26548	761.3	−2.6	6.49	882	12.0	0.0	0.0	0.0	4.73	9.31
Torre de Moncorvo	267	7716	855.5	−2.7	7.29	780	15.2	0.0	0.0	0.0	3.47	6.56
Torres Novas	268	34970	721.3	−2.6	6.15	935	10.8	0.0	0.0	0.0	5.45	10.94
Torres Vedras	269	78220	664.0	−2.1	5.66	1021	9.1	0.0	0.0	0.0	6.79	14.03
Trancoso	270	8946	825.4	−2.7	7.03	810	14.1	0.0	0.0	0.0	3.81	7.30
Trofa	271	38317	733.5	−2.6	6.25	918	11.2	0.0	0.0	0.0	5.21	10.40
Vagos	272	22685	711.1	−2.6	6.06	949	10.5	0.0	0.0	0.0	5.66	11.42
Vale de Cambra	273	21399	739.1	−2.6	6.30	911	11.3	0.0	0.0	0.0	5.11	10.17
Valença	274	13283	748.3	−2.6	6.38	899	11.6	0.0	0.0	0.0	4.95	9.80
Valongo	275	96570	735.7	−2.6	6.27	915	11.2	0.0	0.0	0.0	5.17	10.31
Valpaços	276	14932	842.9	−2.7	7.18	792	14.7	0.0	0.0	0.0	3.61	6.86

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Velas	277	5137	975.8	-2.8	8.32	679	19.7	0.0	0.0	0.0	2.45	4.42
Vendas Novas	278	11259	739.7	-2.6	6.30	910	11.3	0.0	0.0	0.0	5.10	10.15
Viana do Alentejo	279	5142	786.3	-2.6	6.70	852	12.8	0.0	0.0	0.0	4.34	8.45
Viana do Castelo	280	84636	722.5	-2.6	6.16	933	10.8	0.0	0.0	0.0	5.43	10.89
Vidigueira	281	5498	806.8	-2.7	6.88	829	13.5	0.0	0.0	0.0	4.05	7.82
Vieira do Minho	282	11898	776.2	-2.6	6.62	864	12.5	0.0	0.0	0.0	4.49	8.78
Vila da Praia da Vitória	283	21331	876.7	-2.7	7.47	760	15.9	0.0	0.0	0.0	3.25	6.10
Vila de Rei	284	3321	753.8	-2.6	6.42	892	11.8	0.0	0.0	0.0	4.85	9.59
Vila do Bispo	285	5154	755.4	-2.6	6.44	890	11.8	0.0	0.0	0.0	4.82	9.53
Vila do Conde	286	79579	720.4	-2.6	6.14	936	10.8	0.0	0.0	0.0	5.47	10.99
Vila do Porto	287	5623	773.1	-2.6	6.59	868	12.4	0.0	0.0	0.0	4.54	8.89
Vila Flor	288	6073	849.6	-2.7	7.24	785	15.0	0.0	0.0	0.0	3.53	6.70
Vila Franca de Xira	289	141603	689.1	-2.2	5.87	981	9.8	0.0	0.0	0.0	6.15	12.55
Vila Franca do Campo	290	11078	765.8	-2.6	6.53	877	12.2	0.0	0.0	0.0	4.65	9.14
Vila Nova da Barquinha	291	7402	730.6	-2.6	6.23	922	11.1	0.0	0.0	0.0	5.27	10.53
Vila Nova de Cerveira	292	8877	737.7	-2.6	6.29	912	11.3	0.0	0.0	0.0	5.14	10.23
Vila Nova de Famalicão	293	131738	739.6	-2.6	6.30	910	11.3	0.0	0.0	0.0	5.10	10.15
Vila Nova de Foz Côa	294	6541	841.9	-2.7	7.18	793	14.7	0.0	0.0	0.0	3.62	6.88
Vila Nova de Gaia	295	299938	725.6	-2.6	6.18	929	10.9	0.0	0.0	0.0	5.37	10.75
Vila Nova de Paiva	296	4723	794.7	-2.6	6.77	843	13.1	0.0	0.0	0.0	4.22	8.18
Vila Nova de Poiares	297	6929	744.1	-2.6	6.34	904	11.5	0.0	0.0	0.0	5.02	9.97
Vila Pouca de Aguiar	298	12009	813.4	-2.7	6.93	822	13.7	0.0	0.0	0.0	3.97	7.63
Vila Real	299	49868	800.9	-2.6	6.83	836	13.3	0.0	0.0	0.0	4.13	7.99

Table D.1.1: Apophis' seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[\mu m]$	t_e $[pm]$
Vila Real de Santo António	300	18888	872.9	-2.7	7.44	763	15.8	0.0	0.0	0.0	3.29	6.17
Vila Velha de Ródão	301	3167	792.0	-2.6	6.75	846	13.0	0.0	0.0	0.0	4.26	8.27
Vila Verde	302	46865	752.9	-2.6	6.42	893	11.7	0.0	0.0	0.0	4.87	9.62
Vila Viçosa	303	7719	826.6	-2.7	7.04	808	14.2	0.0	0.0	0.0	3.80	7.27
Vimioso	304	4070	906.3	-2.7	7.72	734	17.0	0.0	0.0	0.0	2.98	5.52
Vinhais	305	7847	873.2	-2.7	7.44	763	15.8	0.0	0.0	0.0	3.29	6.17
Viseu	306	96991	777.1	-2.6	6.62	863	12.5	0.0	0.0	0.0	4.48	8.75
Vizela	307	23840	760.3	-2.6	6.48	884	12.0	0.0	0.0	0.0	4.74	9.34
Vouzela	308	9661	760.8	-2.6	6.48	883	12.0	0.0	0.0	0.0	4.73	9.33

Table D.1.2: Apophis' tsunami effects, for all studied municipalities

				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Abrantes	127.0	18	317	5.445	2.51	3.43	4.138	2.19	2.99	6.029	8.35	11.40
Açores	79.0	4	762	5.205	3.88	7.53	3.955	3.38	6.56	5.307	12.37	24.04
Águeda	149.0	450	989	5.140	3.17	4.54	3.906	2.77	3.96	5.121	10.02	14.34
Aguiar da Beira	159.0	111	416	5.065	2.15	2.87	3.849	1.88	2.50	4.914	6.70	8.95
Alandroal	74.0	0	425	5.178	4.11	6.29	3.935	3.58	5.48	5.229	13.05	19.98
Albergaria-a-Velha	47.0	0	227	4.457	6.00	7.70	3.387	5.23	6.71	3.423	16.62	21.34
Albufeira	34.0	0	254	4.795	8.60	11.33	3.644	7.50	9.88	4.210	25.48	33.57
Alcácer do Sal	85.0	43	678	5.429	3.86	6.76	4.125	3.36	5.89	5.977	12.80	22.44
Alcanena	49.0	0	504	5.352	6.30	10.28	4.067	5.50	8.96	5.742	20.65	33.66
Alcobaça	30.0	0	61	5.104	10.05	10.82	3.878	8.76	9.43	5.020	31.53	33.94
Alcochete	112.0	25	379	4.552	2.62	3.75	3.459	2.29	3.27	3.635	7.41	10.59
Alcoutim	106.0	2	666	5.855	3.06	5.59	4.449	2.66	4.87	7.399	10.86	19.86
Alenquer	188.0	150	1199	5.007	1.89	3.97	3.805	1.65	3.46	4.756	5.82	12.24
Alfândega da Fé	146.0	75	1000	5.018	2.24	4.61	3.813	1.95	4.02	4.787	6.92	14.24
Alijó	36.0	0	370	4.730	8.07	11.80	3.594	7.03	10.28	4.049	23.60	34.52
Aljezur	110.0	63	258	5.023	2.93	3.60	3.817	2.56	3.14	4.799	9.07	11.12
Aljustrel	27.0	0	125	5.198	11.27	13.04	3.950	9.83	11.36	5.287	35.96	41.58
Almada	204.0	500	845	5.160	2.42	3.06	3.921	2.11	2.66	5.177	7.65	9.68
Almeida	119.0	5	171	5.674	2.69	3.24	4.311	2.34	2.83	6.770	9.29	11.21
Almeirim	115.0	150	577	4.903	3.05	4.43	3.726	2.66	3.86	4.483	9.23	13.38
Almodôvar	126.0	9	132	5.718	2.56	2.95	4.345	2.23	2.57	6.920	8.91	10.27
Alpiarça	162.0	147	413	5.325	2.25	2.88	4.046	1.96	2.51	5.660	7.34	9.40

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Alter do Chão	110.0	96	618	5.447	3.17	5.02	4.139	2.77	4.38	6.033	10.56	16.71
Alvaiázere	100.0	100	315	4.925	3.33	4.13	3.742	2.91	3.60	4.539	10.12	12.54
Alvito	40.0	50	258	5.377	8.22	10.24	4.086	7.17	8.92	5.818	27.05	33.67
Amadora	101.0	50	1348	5.056	3.16	7.98	3.842	2.75	6.96	4.889	9.82	24.82
Amarante	79.0	24	901	4.990	3.89	8.03	3.792	3.39	7.00	4.712	11.95	24.67
Amares	101.0	13	525	5.390	3.12	5.08	4.096	2.72	4.43	5.858	10.28	16.76
Anadia	9.6	0	1021	3.851	27.29	62.13	2.926	23.79	54.16	2.266	66.20	150.70
Angra do Heroísmo	110.0	175	533	5.489	3.47	4.74	4.171	3.02	4.13	6.167	11.62	15.88
Ansião	81.0	17	1416	4.993	3.76	10.20	3.794	3.28	8.89	4.720	11.57	31.37
Arcos de Valdevez	148.0	75	1418	5.533	2.32	5.88	4.205	2.02	5.13	6.308	7.84	19.87
Arganil	140.0	75	955	5.132	2.36	4.74	3.899	2.06	4.13	5.098	7.45	14.94
Armamar	96.0	50	1222	5.170	3.36	7.99	3.928	2.93	6.97	5.205	10.66	25.36
Arouca	158.0	150	412	5.466	2.35	2.99	4.153	2.05	2.61	6.092	7.83	9.99
Arraiolos	205.0	236	584	5.411	1.96	2.62	4.112	1.71	2.28	5.922	6.49	8.67
Arronches	98.0	44	395	5.822	3.47	4.91	4.424	3.02	4.28	7.283	12.27	17.37
Arruda dos Vinhos	50.0	0	78	5.104	6.03	6.62	3.878	5.26	5.77	5.021	18.92	20.77
Aveiro	152.0	75	245	5.393	2.23	2.66	4.098	1.95	2.32	5.867	7.36	8.79
Avis	118.0	2	194	5.857	2.75	3.40	4.450	2.39	2.97	7.406	9.76	12.10
Azambuja	110.0	50	1416	5.111	2.92	7.60	3.884	2.54	6.63	5.041	9.16	23.87
Baião	52.0	9	488	4.967	5.79	9.21	3.774	5.04	8.03	4.649	17.71	28.19
Barcelos	203.0	125	412	5.024	1.70	2.23	3.817	1.49	1.95	4.801	5.27	6.90
Barrancos	30.0	0	76	5.162	10.11	11.07	3.923	8.82	9.65	5.185	32.05	35.09

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Barreiro	50.0	50	523	5.257	6.51	10.13	3.995	5.67	8.83	5.458	20.96	32.63
Batalha	127.0	25	284	4.992	2.42	3.18	3.794	2.11	2.77	4.717	7.45	9.78
Beja	203.0	446	890	5.485	2.40	3.25	4.168	2.09	2.84	6.153	8.04	10.90
Belmonte	30.0	0	78	5.035	9.99	10.96	3.826	8.71	9.55	4.832	30.94	33.96
Benavente	90.0	11	205	5.850	3.64	4.51	4.446	3.17	3.93	7.383	12.92	16.01
Bombarral	163.0	250	550	5.145	2.44	3.14	3.909	2.13	2.73	5.135	7.70	9.91
Borba	134.0	250	1270	4.977	2.92	5.75	3.782	2.54	5.01	4.676	8.94	17.63
Boticas	70.0	22	572	4.981	4.37	7.30	3.785	3.81	6.36	4.687	13.42	22.40
Braga	220.0	325	1489	5.048	1.92	3.90	3.836	1.67	3.40	4.867	5.95	12.12
Bragança	105.0	150	1200	4.989	3.37	7.10	3.791	2.94	6.19	4.707	10.36	21.81
Cabeceiras de Basto	94.0	46	665	5.841	3.63	6.29	4.438	3.16	5.48	7.348	12.88	22.30
Cadaval	36.0	0	255	5.350	8.58	11.31	4.065	7.48	9.86	5.734	28.09	37.04
Caldas da Rainha	3.5	0	942	3.547	71.85	156.45	2.695	62.63	136.38	1.796	161.68	352.06
Calheta (Açores)	3.1	0	1640	4.441	90.76	276.83	3.374	79.12	241.32	3.389	250.73	764.72
Calheta (Madeira)	3.8	0	1862	4.411	73.79	245.55	3.352	64.33	214.05	3.324	202.59	674.12
Câmara de Lobos	42.0	0	805	4.949	7.07	14.19	3.761	6.17	12.37	4.603	21.57	43.27
Caminha	202.0	173	341	5.217	1.84	2.15	3.964	1.60	1.88	5.340	5.88	6.89
Campo Maior	75.0	0	137	5.292	4.10	4.80	4.021	3.57	4.18	5.561	13.28	15.55
Cantanhede	169.0	75	898	5.092	1.95	3.78	3.869	1.70	3.30	4.988	6.10	11.84
Carrazeda de Ansiães	115.0	150	375	5.203	3.14	3.89	3.953	2.74	3.39	5.300	10.04	12.41
Carregal do Sal	120.0	3	130	5.820	2.69	3.12	4.422	2.35	2.72	7.275	9.53	11.03
Cartaxo	24.0	0	475	5.363	12.88	20.53	4.075	11.23	17.90	5.774	42.28	67.38

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Cascais	131.0	350	1205	5.505	3.44	5.99	4.183	3.00	5.22	6.217	11.55	20.14
Castanheira de Pêra	191.0	121	1227	5.491	1.89	4.15	4.173	1.64	3.62	6.174	6.32	13.92
Castelo Branco	95.0	25	694	5.157	3.29	5.96	3.918	2.87	5.20	5.169	10.42	18.87
Castelo de Paiva	186.0	125	825	5.399	1.93	3.39	4.103	1.68	2.95	5.886	6.37	11.19
Castelo de Vide	121.0	200	1375	5.167	3.14	6.82	3.926	2.73	5.94	5.197	9.94	21.63
Castro Daire	82.0	0	276	4.310	3.38	4.55	3.275	2.95	3.96	3.114	9.09	12.22
Castro Marim	123.0	125	288	5.025	2.81	3.31	3.819	2.45	2.88	4.805	8.70	10.23
Castro Verde	165.0	375	1256	5.179	2.70	4.73	3.936	2.36	4.13	5.234	8.60	15.05
Celorico da Beira	102.0	75	851	4.995	3.20	6.04	3.796	2.79	5.26	4.725	9.84	18.57
Celorico de Basto	102.0	11	200	5.429	3.09	3.81	4.126	2.70	3.32	5.979	10.26	12.65
Chamusca	151.0	300	1050	4.975	2.71	4.56	3.781	2.36	3.98	4.672	8.31	13.98
Chaves	110.0	12	1381	5.160	2.80	7.52	3.921	2.44	6.55	5.178	8.87	23.81
Cinfães	115.0	9	500	5.516	2.76	4.43	4.192	2.40	3.86	6.252	9.28	14.92
Coimbra	110.0	12	466	5.534	2.90	4.52	4.206	2.53	3.94	6.311	9.79	15.26
Condeixa-a-Nova	110.0	22	224	5.397	2.90	3.61	4.101	2.53	3.15	5.879	9.56	11.91
Constância	145.0	7	264	5.816	2.24	2.95	4.420	1.95	2.57	7.261	7.92	10.44
Coruche	3.4	0	718	2.811	65.84	124.93	2.136	57.39	108.90	0.931	119.84	227.39
Corvo	199.0	375	1993	5.570	2.33	5.53	4.233	2.03	4.82	6.428	7.90	18.78
Covilhã	161.0	150	445	5.316	2.27	2.98	4.040	1.98	2.59	5.633	7.39	9.69
Crato	124.0	150	309	5.020	2.87	3.34	3.815	2.50	2.92	4.792	8.85	10.33
Cuba	187.0	150	496	5.147	1.92	2.62	3.911	1.68	2.29	5.142	6.08	8.29
Elvas	102.0	25	87	5.427	3.14	3.38	4.124	2.74	2.95	5.970	10.43	11.21

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Entroncamento	62.0	0	100	5.150	4.89	5.50	3.914	4.26	4.79	5.151	15.46	17.39
Espinho	36.0	0	281	4.949	8.25	11.15	3.761	7.19	9.72	4.603	25.16	34.00
Esposende	64.0	0	130	5.153	4.74	5.51	3.916	4.13	4.80	5.159	14.99	17.42
Estarreja	200.0	205	653	5.556	1.98	2.86	4.222	1.72	2.49	6.382	6.70	9.69
Estremoz	153.0	150	441	5.333	2.39	3.13	4.052	2.09	2.73	5.683	7.81	10.21
Évora	89.0	175	894	4.988	4.08	7.10	3.791	3.56	6.18	4.706	12.54	21.79
Fafe	49.0	0	410	4.304	5.65	8.55	3.270	4.93	7.45	3.101	15.18	22.95
Faro	82.0	145	575	4.967	4.29	6.24	3.775	3.74	5.44	4.651	13.12	19.09
Felgueiras	105.0	24	277	4.944	2.91	3.81	3.757	2.54	3.32	4.590	8.87	11.60
Ferreira do Alentejo	115.0	125	451	5.421	3.13	4.23	4.120	2.72	3.69	5.954	10.36	14.01
Ferreira do Zêzere	72.0	0	257	5.470	4.34	5.73	4.156	3.78	5.00	6.105	14.49	19.15
Figueira da Foz	200.0	124	976	5.152	1.75	3.36	3.915	1.53	2.93	5.155	5.54	10.64
Figueira de Castelo Rodrigo	120.0	125	1009	5.457	3.01	5.88	4.146	2.62	5.12	6.064	10.02	19.59
Figueiró dos Vinhos	154.0	325	915	5.193	2.78	4.24	3.946	2.42	3.69	5.273	8.85	13.50
Fornos de Algodres	214.0	124	885	5.138	1.63	2.98	3.905	1.42	2.60	5.117	5.16	9.40
Freixo de Espada à Cinta	175.0	150	371	5.412	2.11	2.60	4.113	1.84	2.26	5.926	6.97	8.60
Fronteira	3.1	0	1818	4.389	90.24	295.29	3.335	78.66	257.41	3.278	246.62	807.05
Fundão	198.0	275	1227	5.563	2.14	4.03	4.228	1.86	3.51	6.405	7.25	13.67
Gavião	143.0	50	312	5.387	2.30	3.01	4.094	2.01	2.63	5.848	7.59	9.93
Góis	144.0	150	1204	5.542	2.59	5.47	4.211	2.26	4.77	6.337	8.77	18.49
Golegã	100.0	14	95	5.419	3.16	3.48	4.118	2.76	3.03	5.947	10.48	11.52
Gondomar	70.0	5	470	5.122	4.34	6.85	3.892	3.79	5.97	5.070	13.67	21.56

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Gouveia	168.0	250	1626	5.353	2.41	5.58	4.067	2.10	4.86	5.743	7.91	18.26
Grândola	38.0	0	325	4.816	7.71	10.84	3.660	6.72	9.45	4.262	22.94	32.26
Guarda	184.0	441	1287	5.254	2.58	4.34	3.993	2.25	3.78	5.450	8.31	13.98
Guimarães	79.0	83	613	4.993	4.17	6.67	3.794	3.63	5.81	4.719	12.82	20.51
Horta	15.0	0	1043	3.398	16.41	37.80	2.582	14.30	32.95	1.592	35.51	81.82
Idanha-a-Nova	215.0	125	828	5.517	1.69	2.97	4.192	1.47	2.59	6.256	5.68	10.00
Ílhavo	48.0	0	61	5.107	6.29	6.77	3.881	5.48	5.90	5.029	19.73	21.23
Lagoa (Açores)	12.0	0	947	4.442	23.45	51.21	3.376	20.44	44.64	3.393	64.81	141.53
Lagoa (Faro)	36.0	0	103	4.501	7.87	8.88	3.420	6.86	7.74	3.520	22.01	24.84
Lagos	50.0	0	255	4.691	5.78	7.63	3.564	5.04	6.65	3.956	16.80	22.15
Lajes das Flores	4.6	0	830	2.794	48.52	98.86	2.123	42.30	86.18	0.916	87.84	178.98
Lajes do Pico	4.5	0	2351	3.880	58.45	230.22	2.949	50.95	200.68	2.315	142.77	562.34
Lamego	133.0	50	1122	5.155	2.42	5.48	3.917	2.11	4.77	5.164	7.67	17.33
Leiria	50.0	0	410	5.246	6.12	9.25	3.986	5.33	8.06	5.425	19.67	29.75
Lisboa	30.0	0	228	5.212	10.16	13.06	3.961	8.86	11.38	5.328	32.49	41.75
Loulé	44.0	0	589	4.343	6.32	10.98	3.300	5.51	9.57	3.183	17.12	29.73
Loures	30.0	0	409	5.255	10.20	15.42	3.993	8.89	13.44	5.451	32.86	49.66
Lourinhã	72.0	0	201	5.802	4.47	5.59	4.409	3.89	4.87	7.213	15.75	19.71
Lousã	130.0	75	1205	5.522	2.64	6.05	4.196	2.30	5.27	6.272	8.90	20.39
Lousada	85.0	175	578	5.056	4.31	6.08	3.842	3.75	5.30	4.890	13.39	18.92
Mação	108.0	47	643	5.148	2.97	5.06	3.912	2.59	4.41	5.145	9.39	16.00
Macedo de Cavaleiros	192.0	225	1263	5.008	1.99	4.01	3.805	1.74	3.50	4.759	6.15	12.37

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$	Collapse wave A_{800} $[mm]$	Collapse wave U_{min} $[cm]$	Collapse wave U_{max} $[cm]$
Machico	5.3	0	1480	4.464	53.23	151.70	3.392	46.40	132.24	3.439	147.75	421.09
Madalena	9.6	0	2351	3.409	25.68	101.15	2.590	22.39	88.17	1.606	55.74	219.53
Madeira	65.0	0	431	5.701	4.90	7.55	4.332	4.28	6.58	6.863	17.02	26.19
Mafra	59.0	35	255	5.078	5.32	6.73	3.858	4.64	5.86	4.948	16.62	20.99
Maia	132.0	225	766	5.168	2.95	4.50	3.927	2.57	3.92	5.200	9.35	14.28
Mangualde	171.0	518	1993	5.346	2.97	6.30	4.062	2.59	5.49	5.723	9.73	20.62
Manteigas	100.0	8	962	5.103	3.05	6.64	3.878	2.66	5.79	5.019	9.55	20.84
Marco de Canaveses	47.0	0	165	5.310	6.55	7.90	4.035	5.71	6.88	5.616	21.29	25.68
Marinha Grande	164.0	200	1027	5.163	2.31	4.22	3.923	2.02	3.68	5.187	7.33	13.39
Marvão	52.0	0	134	5.076	5.79	6.75	3.857	5.04	5.89	4.945	18.06	21.08
Matosinhos	108.0	25	568	5.467	2.98	4.94	4.155	2.60	4.31	6.098	9.96	16.51
Mealhada	179.0	225	945	5.175	2.17	3.70	3.932	1.90	3.23	5.220	6.91	11.76
Mêda	99.0	25	1336	4.975	3.10	8.03	3.780	2.70	7.00	4.670	9.51	24.61
Melgaço	157.0	25	371	5.000	1.96	2.78	3.799	1.71	2.43	4.737	6.04	8.57
Mértola	123.0	50	1038	5.109	2.61	5.64	3.882	2.27	4.91	5.035	8.18	17.70
Mesão Frio	74.0	0	64	5.379	4.19	4.52	4.088	3.65	3.94	5.825	13.77	14.87
Mira	118.0	50	940	5.481	2.81	5.76	4.165	2.45	5.02	6.139	9.42	19.28
Miranda do Corvo	248.0	400	911	5.011	1.81	2.58	3.808	1.58	2.25	4.768	5.58	7.95
Miranda do Douro	173.0	175	941	5.012	2.11	3.76	3.808	1.84	3.28	4.770	6.50	11.60
Mirandela	211.0	150	997	5.025	1.68	3.19	3.819	1.47	2.78	4.805	5.21	9.85
Mogadouro	149.0	375	1011	5.170	2.99	4.61	3.928	2.61	4.02	5.206	9.50	14.64
Moimenta da Beira	30.0	0	58	5.106	10.06	10.79	3.880	8.77	9.40	5.026	31.55	33.84

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$	Collapse wave A_{800} $[mm]$	Collapse wave U_{min} $[cm]$	Collapse wave U_{max} $[cm]$
Moita	75.0	9	1114	4.935	4.00	9.46	3.750	3.49	8.25	4.567	12.17	28.78
Monção	75.0	25	902	4.856	4.05	8.35	3.690	3.53	7.28	4.361	12.12	25.01
Monchique	103.0	100	1307	4.971	3.25	7.61	3.777	2.83	6.64	4.659	9.95	23.31
Mondim de Basto	191.0	225	402	5.394	2.08	2.44	4.099	1.81	2.13	5.870	6.86	8.05
Monforte	133.0	175	1527	5.016	2.74	6.54	3.812	2.39	5.70	4.782	8.46	20.19
Montalegre	132.0	25	424	5.397	2.42	3.60	4.101	2.11	3.13	5.878	8.00	11.87
Montemor-o-Novo	95.0	2	127	5.541	3.32	3.83	4.211	2.89	3.34	6.333	11.21	12.96
Montemor-o-Velho	30.0	0	135	5.104	10.06	11.75	3.879	8.77	10.24	5.022	31.54	36.86
Montijo	176.0	38	206	5.815	1.92	2.30	4.419	1.67	2.01	7.257	6.77	8.13
Mora	127.0	75	768	5.472	2.69	4.82	4.158	2.34	4.20	6.111	8.99	16.11
Mortágua	163.0	75	584	5.026	2.01	3.18	3.819	1.75	2.77	4.806	6.21	9.82
Moura	148.0	100	286	4.896	2.25	2.71	3.721	1.96	2.36	4.465	6.78	8.18
Mourão	146.0	175	1031	4.987	2.49	4.67	3.790	2.17	4.07	4.703	7.64	14.35
Murça	47.0	0	17	5.067	6.39	6.53	3.850	5.57	5.69	4.918	19.92	20.35
Murtosa	22.0	0	177	5.197	13.84	16.90	3.949	12.06	14.73	5.285	44.12	53.88
Nazaré	129.0	150	484	5.209	2.81	3.79	3.958	2.45	3.31	5.319	8.96	12.12
Nelas	153.0	50	463	5.270	2.13	3.16	4.004	1.86	2.76	5.495	6.87	10.21
Nisa	11.0	0	1103	4.672	26.24	62.41	3.550	22.87	54.41	3.912	75.92	180.60
Nordeste	27.0	0	222	5.285	11.37	14.52	4.016	9.91	12.66	5.539	36.81	47.02
Óbidos	48.0	0	515	4.794	6.09	10.01	3.643	5.31	8.73	4.206	18.04	29.66
Odemira	64.0	24	339	5.555	5.06	7.00	4.221	4.42	6.10	6.379	17.16	23.72
Odivelas	25.0	0	199	5.290	12.28	15.34	4.020	10.71	13.37	5.556	39.81	49.71

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Oeiras	130.0	250	1085	5.280	3.10	5.56	4.012	2.70	4.85	5.526	10.02	17.99
Oleiros	68.0	0	410	4.370	4.10	6.21	3.320	3.58	5.41	3.238	11.17	16.90
Olhão	72.0	25	645	5.143	4.34	7.60	3.908	3.78	6.62	5.130	13.70	23.99
Oliveira de Azeméis	95.0	50	1062	5.138	3.39	7.42	3.904	2.95	6.46	5.117	10.68	23.40
Oliveira de Frades	86.0	5	78	5.301	3.60	3.92	4.028	3.14	3.42	5.588	11.68	12.74
Oliveira do Bairro	159.0	150	1244	5.478	2.33	5.02	4.163	2.03	4.38	6.132	7.81	16.80
Oliveira do Hospital	91.0	95	678	5.434	3.83	6.32	4.129	3.34	5.51	5.992	12.71	20.98
Ourém	108.0	65	377	4.989	2.99	4.06	3.791	2.60	3.54	4.708	9.17	12.48
Ourique	57.0	0	225	5.121	5.30	6.79	3.892	4.62	5.92	5.069	16.68	21.37
Ovar	77.0	175	570	5.056	4.75	6.68	3.842	4.14	5.82	4.888	14.78	20.76
Paços de Ferreira	29.0	0	391	5.027	10.32	15.37	3.820	9.00	13.40	4.810	31.93	47.54
Palmela	154.0	300	1418	5.513	2.80	5.64	4.190	2.44	4.92	6.244	9.42	19.00
Pampilhosa da Serra	83.0	25	519	5.085	3.74	5.98	3.864	3.26	5.21	4.969	11.69	18.70
Paredes	70.0	125	883	4.986	4.92	8.96	3.789	4.29	7.81	4.699	15.12	27.51
Paredes de Coura	133.0	150	779	5.474	2.79	4.64	4.160	2.43	4.04	6.119	9.33	15.50
Pedrógão Grande	126.0	36	550	5.508	2.60	4.20	4.185	2.27	3.66	6.225	8.74	14.11
Penacova	84.0	22	586	5.062	3.67	6.20	3.846	3.20	5.40	4.905	11.44	19.29
Penafiel	132.0	325	724	5.121	3.22	4.36	3.891	2.81	3.80	5.068	10.13	13.72
Penalva do Castelo	224.0	300	1076	5.543	1.93	3.29	4.212	1.68	2.87	6.340	6.53	11.13
Penamacor	170.0	450	1000	5.188	2.80	4.03	3.942	2.44	3.51	5.258	8.90	12.81
Penedono	115.0	150	873	5.493	3.23	5.69	4.174	2.82	4.96	6.180	10.84	19.09
Penela	16.0	0	165	5.352	19.31	23.29	4.067	16.83	20.30	5.742	63.24	76.28

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$	Collapse wave A_{800} $[mm]$	Collapse wave U_{min} $[cm]$	Collapse wave U_{max} $[cm]$
Peniche	130.0	50	1397	5.108	2.47	6.37	3.881	2.15	5.56	5.031	7.74	20.01
Peso da Régua	190.0	150	926	5.152	1.89	3.44	3.915	1.65	3.00	5.155	5.99	10.89
Pinhel	65.0	0	560	5.247	4.71	8.00	3.987	4.10	6.97	5.429	15.14	25.73
Pombal	14.0	0	873	4.406	20.02	41.87	3.348	17.45	36.50	3.315	54.91	114.83
Ponta do Sol	4.3	0	1620	4.429	65.35	197.67	3.365	56.96	172.31	3.363	180.07	544.70
Ponte da Barca	80.0	25	1359	4.999	3.85	10.07	3.798	3.35	8.78	4.734	11.84	30.99
Ponte de Lima	66.0	3	835	5.003	4.54	9.25	3.802	3.96	8.06	4.745	13.99	28.48
Ponte de Sôr	138.0	46	285	5.382	2.37	3.04	4.090	2.07	2.65	5.832	7.81	10.02
Portalegre	188.0	250	1027	5.389	2.16	3.77	4.095	1.89	3.28	5.854	7.13	12.41
Portel	132.0	100	424	4.988	2.54	3.46	3.790	2.22	3.01	4.706	7.81	10.62
Portimão	46.0	0	325	4.605	6.23	8.76	3.500	5.43	7.64	3.756	17.79	25.02
Porto	56.0	0	157	5.063	5.37	6.42	3.848	4.68	5.59	4.909	16.71	19.98
Porto de Mós	44.0	50	615	5.202	7.35	12.24	3.953	6.41	10.67	5.298	23.47	39.07
Porto Moniz	4.0	0	1640	4.545	71.17	217.06	3.454	62.04	189.22	3.619	200.82	612.51
Porto Santo	6.3	0	517	4.683	45.87	75.51	3.559	39.98	65.82	3.938	133.00	218.94
Póvoa de Lanhoso	83.0	50	743	4.981	3.81	6.93	3.785	3.33	6.04	4.687	11.70	21.24
Póvoa de Varzim	33.0	0	202	4.946	9.00	11.27	3.758	7.84	9.82	4.594	27.43	34.35
Povoação	5.4	0	1103	4.570	52.86	125.74	3.473	46.08	109.61	3.675	149.89	356.54
Proença-a-Nova	128.0	114	954	5.268	2.74	5.25	4.003	2.38	4.58	5.490	8.83	16.95
Redondo	152.0	187	653	5.097	2.45	3.60	3.873	2.13	3.14	5.003	7.67	11.28
Reguengos de Monsaraz	133.0	100	363	4.914	2.50	3.24	3.734	2.18	2.82	4.510	7.58	9.80
Resende	116.0	50	1218	5.122	2.77	6.57	3.892	2.41	5.73	5.072	8.71	20.68

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Ribeira Brava	3.8	0	1725	4.419	73.86	233.14	3.358	64.39	203.23	3.342	203.14	641.15
Ribeira de Pena	121.0	153	1286	4.993	2.94	6.43	3.794	2.56	5.60	4.719	9.03	19.77
Ribeira Grande	8.2	0	877	4.463	34.40	72.11	3.392	29.99	62.86	3.438	95.48	200.14
Rio Maior	97.0	25	497	5.741	3.40	5.35	4.363	2.97	4.66	7.001	11.88	18.67
Sabrosa	143.0	75	1100	5.060	2.30	4.99	3.845	2.00	4.35	4.898	7.15	15.52
Sabugal	225.0	450	1223	5.487	2.17	3.52	4.169	1.89	3.06	6.159	7.28	11.78
Salvaterra de Magos	89.0	2	105	5.514	3.53	3.99	4.190	3.08	3.47	6.246	11.89	13.41
Santa Comba Dão	132.0	137	352	5.441	2.76	3.40	4.134	2.41	2.96	6.014	9.19	11.30
Santa Cruz	3.7	0	1415	4.427	75.93	210.24	3.364	66.19	183.27	3.360	209.18	579.16
Santa Cruz da Graciosa	8.7	0	402	3.598	29.11	43.74	2.734	25.38	38.13	1.870	66.36	99.71
Santa Cruz das Flores	3.4	0	914	2.802	65.74	140.85	2.129	57.31	122.78	0.923	119.33	255.66
Santa Maria da Feira	73.0	25	450	5.188	4.30	6.51	3.942	3.74	5.67	5.257	13.68	20.72
Santa Marta de Penaguião	130.0	75	1416	5.109	2.54	6.43	3.882	2.21	5.61	5.036	7.97	20.19
Santana	7.2	0	1862	4.522	39.44	131.23	3.436	34.38	114.39	3.568	110.77	368.59
Santarém	130.0	3	529	5.840	2.49	4.12	4.438	2.17	3.59	7.345	8.84	14.62
Santiago do Cacém	38.0	0	370	4.857	7.74	11.33	3.691	6.75	9.87	4.365	23.21	33.95
Santo Tirso	61.0	36	535	4.987	5.11	8.16	3.790	4.45	7.11	4.704	15.69	25.05
São Brás de Alportel	45.0	125	530	4.293	7.11	10.22	3.262	6.20	8.91	3.079	19.04	27.37
São João da Madeira	74.0	150	276	5.167	4.87	5.52	3.926	4.25	4.81	5.198	15.45	17.50
São João da Pesqueira	164.0	75	994	5.128	2.02	4.13	3.897	1.76	3.60	5.089	6.35	13.03
São Pedro do Sul	104.0	75	1119	5.140	3.18	6.98	3.905	2.78	6.09	5.121	10.05	22.04
São Roque do Pico	4.8	0	2351	4.373	58.17	229.13	3.323	50.71	199.74	3.246	158.48	624.22

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} [km]	h_{min} [m]	h_{max} [m]	Rumpf Rim-wave A_{800} [m]	Rumpf Rim-wave U_{min} [m]	Rumpf Rim-wave U_{max} [m]	Collins Rim-wave A_{800} [m]	Collins Rim-wave U_{min} [m]	Collins Rim-wave U_{max} [m]	Collapse wave A_{800} [mm]	Collapse wave U_{min} [cm]	Collapse wave U_{max} [cm]
São Vicente	4.7	0	1725	4.509	60.32	190.40	3.426	52.58	165.97	3.537	168.97	533.30
Sardoal	111.0	75	452	5.286	3.02	4.33	4.017	2.64	3.77	5.544	9.80	14.02
Sátão	132.0	375	859	5.137	3.37	4.75	3.904	2.94	4.14	5.115	10.63	15.00
Seia	163.0	175	1993	5.399	2.32	6.64	4.102	2.02	5.79	5.883	7.66	21.94
Seixal	30.0	0	81	5.178	10.13	11.15	3.934	8.83	9.72	5.228	32.18	35.44
Sernancelhe	152.0	475	964	5.122	3.17	4.38	3.892	2.76	3.82	5.071	9.97	13.79
Serpa	159.0	25	523	5.048	1.95	3.12	3.836	1.70	2.72	4.867	6.04	9.69
Sertã	132.0	125	1084	5.429	2.73	5.55	4.125	2.38	4.84	5.977	9.04	18.42
Sesimbra	9.9	0	380	4.989	30.12	44.43	3.791	26.26	38.73	4.708	92.54	136.50
Setúbal	29.0	0	501	5.020	10.32	16.78	3.815	8.99	14.62	4.791	31.87	51.83
Sever do Vouga	81.0	25	841	5.155	3.86	7.68	3.917	3.36	6.69	5.163	12.21	24.30
Silves	38.0	0	426	4.520	7.47	11.45	3.434	6.51	9.98	3.561	20.97	32.14
Sines	41.0	0	250	4.969	7.26	9.53	3.776	6.33	8.31	4.654	22.22	29.16
Sintra	37.0	0	528	5.461	8.43	14.00	4.149	7.35	12.20	6.076	28.13	46.70
Sobral de Monte Agraço	93.0	125	442	5.841	4.01	5.39	4.438	3.50	4.70	7.349	14.23	19.11
Soure	96.0	6	532	5.508	3.29	5.43	4.185	2.87	4.74	6.226	11.06	18.27
Sousel	175.0	150	454	5.419	2.11	2.78	4.117	1.84	2.43	5.945	6.99	9.22
Tábua	145.0	143	518	5.481	2.54	3.55	4.165	2.22	3.10	6.141	8.51	11.89
Tabuaço	152.0	75	985	5.144	2.18	4.45	3.909	1.90	3.88	5.134	6.88	14.04
Tarouca	137.0	325	1102	5.179	3.12	5.27	3.935	2.72	4.60	5.231	9.91	16.76
Tavira	52.0	0	541	4.220	5.27	8.84	3.206	4.60	7.71	2.933	13.91	23.31
Terras de Bouro	87.0	75	1525	5.006	3.76	9.98	3.804	3.27	8.70	4.754	11.57	30.76

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
				A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Tomar	89.0	32	350	5.283	3.59	4.96	4.014	3.13	4.32	5.534	11.61	16.04
Tondela	121.0	133	1075	5.303	2.96	5.96	4.029	2.58	5.19	5.593	9.62	19.34
Torre de Moncorvo	190.0	100	920	5.101	1.79	3.41	3.876	1.56	2.97	5.014	5.60	10.70
Torres Novas	88.0	13	678	5.361	3.57	6.49	4.074	3.11	5.66	5.768	11.71	21.29
Torres Vedras	71.0	0	394	5.726	4.50	6.72	4.351	3.92	5.85	6.946	15.67	23.39
Trancoso	166.0	425	986	5.149	2.79	4.07	3.912	2.44	3.55	5.147	8.84	12.88
Trofa	54.0	25	250	4.996	5.70	7.25	3.796	4.97	6.32	4.727	17.53	22.31
Vagos	51.0	0	68	5.143	5.94	6.44	3.908	5.18	5.62	5.131	18.75	20.35
Vale de Cambra	81.0	75	1046	5.159	4.10	8.64	3.920	3.57	7.53	5.176	12.97	27.37
Valença	65.0	0	784	4.968	4.58	9.07	3.775	3.99	7.90	4.653	14.01	27.74
Valongo	69.0	50	385	5.092	4.64	6.47	3.869	4.04	5.64	4.988	14.52	20.24
Valpaços	164.0	225	1148	5.001	2.33	4.43	3.800	2.03	3.86	4.739	7.18	13.65
Velas	3.0	0	1053	3.490	83.15	192.59	2.652	72.48	167.88	1.716	184.36	427.02
Vendas Novas	106.0	25	190	5.357	3.01	3.61	4.071	2.62	3.15	5.757	9.86	11.83
Viana do Alentejo	99.0	72	374	4.940	3.27	4.40	3.754	2.85	3.83	4.578	9.95	13.39
Viana do Castelo	35.0	0	823	4.938	8.48	17.20	3.752	7.39	14.99	4.574	25.80	52.34
Vidigueira	122.0	75	412	4.957	2.67	3.69	3.767	2.32	3.22	4.625	8.14	11.28
Vieira do Minho	95.0	75	1262	4.984	3.43	8.09	3.787	2.99	7.05	4.695	10.53	24.82
Vila da Praia da Vitória	22.0	0	808	3.972	12.10	24.31	3.019	10.54	21.19	2.474	30.19	60.67
Vila de Rei	128.0	125	594	5.425	2.81	4.23	4.122	2.45	3.69	5.965	9.32	14.04
Vila do Bispo	15.0	0	156	4.585	19.06	22.78	3.484	16.62	19.86	3.710	54.22	64.79
Vila do Conde	41.0	0	235	4.997	7.28	9.42	3.797	6.35	8.21	4.731	22.40	28.98

Table D.1.2: Apophis' tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} [km]	h_{min} [m]	h_{max} [m]	A_{800} [m]	U_{min} [m]	U_{max} [m]	A_{800} [m]	U_{min} [m]	U_{max} [m]	A_{800} [mm]	U_{min} [cm]	U_{max} [cm]
Vila do Porto	5.0	0	587	4.420	56.14	97.34	3.359	48.94	84.85	3.345	154.44	267.76
Vila Flor	177.0	123	837	5.048	1.96	3.47	3.836	1.70	3.02	4.866	6.07	10.77
Vila Franca de Xira	30.0	0	378	5.151	10.10	14.87	3.914	8.81	12.97	5.153	31.95	47.05
Vila Franca do Campo	7.7	0	947	4.479	36.70	80.14	3.403	31.99	69.86	3.471	102.16	223.09
Vila Nova da Barquinha	103.0	19	201	5.409	3.09	3.77	4.110	2.69	3.29	5.917	10.21	12.48
Vila Nova de Cerveira	54.0	0	638	4.966	5.51	9.90	3.773	4.80	8.63	4.647	16.86	30.30
Vila Nova de Famalicão	60.0	25	462	4.996	5.13	7.85	3.796	4.47	6.84	4.726	15.78	24.13
Vila Nova de Foz Côa	189.0	82	814	5.200	1.78	3.25	3.951	1.55	2.83	5.291	5.67	10.37
Vila Nova de Gaia	60.0	0	262	5.100	5.03	6.67	3.876	4.38	5.82	5.011	15.75	20.91
Vila Nova de Paiva	133.0	550	1036	5.131	3.84	5.22	3.899	3.35	4.55	5.097	12.09	16.45
Vila Nova de Poiares	125.0	42	458	5.484	2.63	3.93	4.167	2.29	3.43	6.149	8.82	13.17
Vila Pouca de Aguiar	133.0	225	1205	4.990	2.87	5.62	3.792	2.50	4.90	4.711	8.83	17.27
Vila Real	127.0	125	1350	5.038	2.73	6.34	3.828	2.38	5.53	4.840	8.46	19.66
Vila Real de Santo António	81.0	0	225	4.287	3.41	4.37	3.258	2.98	3.81	3.068	9.13	11.70
Vila Velha de Ródão	139.0	50	570	5.199	2.33	3.75	3.951	2.03	3.27	5.291	7.42	11.97
Vila Verde	72.0	21	789	4.986	4.25	8.23	3.789	3.70	7.17	4.701	13.05	25.26
Vila Viçosa	163.0	165	475	5.116	2.24	2.95	3.888	1.95	2.57	5.055	7.03	9.28
Vimioso	228.0	250	955	5.005	1.72	2.87	3.803	1.50	2.51	4.751	5.30	8.86
Vinhais	198.0	275	1273	5.028	2.03	3.92	3.821	1.77	3.42	4.813	6.29	12.12
Viseu	121.0	200	899	5.175	3.14	5.33	3.932	2.74	4.65	5.220	9.97	16.93
Vizela	74.0	125	478	4.947	4.64	6.41	3.759	4.05	5.59	4.597	14.15	19.54
Vouzela	103.0	125	1043	5.161	3.41	6.78	3.922	2.97	5.91	5.182	10.79	21.50

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_{seis}	V_p $[10^{-5}]$	C_p
Abrantes	5.3	0	3.39	1	4.6	0	2.35	0	1.5	0	4.45	1
Açores	5.5	0	3.39	1	4.9	0	2.35	1	1.6	0	4.46	2
Águeda	4.6	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Aguiar da Beira	4.4	0	3.39	0	3.9	0	2.34	0	1.1	0	4.44	0
Alandroal	5.5	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	1
Albergaria-a-Velha	4.6	0	3.39	1	4.1	0	2.35	0	1.2	0	4.45	1
Albufeira	5.4	0	3.39	0	4.7	0	2.35	0	1.6	0	4.46	0
Alcácer do Sal	5.8	0	3.40	0	5.1	0	2.35	0	1.7	0	4.46	0
Alcanena	14.8	0	3.40	1	13.1	0	2.36	1	7.2	0	4.47	2
Alcobaça	12.8	0	3.40	0	11.4	0	2.35	0	5.8	0	4.46	0
Alcochete	4.1	0	3.38	0	3.6	0	2.34	0	1.0	0	4.44	0
Alcoutim	14.4	0	3.40	1	12.7	0	2.35	1	6.9	0	4.47	1
Alenquer	4.1	0	3.38	0	3.6	0	2.34	0	1.0	0	4.44	0
Alfândega da Fé	4.5	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Alijó	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Aljezur	4.8	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Aljustrel	15.4	0	3.40	5	13.6	0	2.36	3	7.6	0	4.47	7
Almada	4.1	0	3.38	0	3.6	0	2.34	0	1.0	0	4.44	0
Almeida	5.7	0	3.39	0	5.0	0	2.35	0	1.7	0	4.46	1
Almeirim	4.6	0	3.39	0	4.1	0	2.35	0	1.2	0	4.45	0
Almodôvar	5.7	0	3.39	0	5.0	0	2.35	0	1.7	0	4.46	0
Alpiarça	4.7	0	3.39	0	4.1	0	2.35	0	1.3	0	4.45	0

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Alter do Chão	5.5	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Alvaiázere	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Alvito	17.1	0	3.40	6	15.2	0	2.36	4	9.0	0	4.47	8
Amadora	5.0	0	3.39	1	4.4	0	2.35	1	1.4	0	4.45	2
Amarante	5.1	0	3.39	0	4.5	0	2.35	0	1.5	0	4.45	0
Amares	5.5	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	1
Anadia	3.9	0	3.38	1	3.4	0	2.34	0	0.9	0	4.44	1
Angra do Heroísmo	5.6	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
Ansião	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Arcos de Valdevez	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Arganil	4.7	0	3.39	0	4.1	0	2.35	0	1.3	0	4.45	0
Armamar	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Arouca	4.9	0	3.39	0	4.3	0	2.35	0	1.4	0	4.45	0
Arraiolos	4.4	0	3.39	0	3.9	0	2.34	0	1.1	0	4.44	0
Arronches	15.2	0	3.40	0	13.5	0	2.36	0	7.5	0	4.47	0
Arruda dos Vinhos	5.7	0	3.39	2	5.1	0	2.35	1	1.7	0	4.46	3
Aveiro	4.9	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Avis	12.5	0	3.40	0	11.0	0	2.35	0	5.5	0	4.46	1
Azambuja	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Baião	5.5	0	3.39	3	4.8	0	2.35	2	1.6	0	4.46	5
Barcelos	4.0	0	3.38	0	3.5	0	2.34	0	1.0	0	4.44	0
Barrancos	14.1	0	3.40	2	12.5	0	2.35	1	6.7	0	4.47	3

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Barreiro	12.7	0	3.40	0	11.3	0	2.35	0	5.7	0	4.46	0
Batalha	4.6	0	3.39	1	4.1	0	2.35	0	1.2	0	4.45	1
Beja	4.5	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Belmonte	5.9	0	3.40	1	5.2	0	2.35	0	1.8	0	4.46	1
Benavente	17.3	0	3.40	0	15.4	0	2.36	0	9.1	0	4.47	0
Bombarral	4.5	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Borba	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Boticas	5.2	0	3.39	6	4.6	0	2.35	4	1.5	0	4.45	8
Braga	3.8	0	3.38	1	3.4	0	2.34	0	0.9	0	4.44	1
Bragança	4.8	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Cabeceiras de Basto	16.3	0	3.40	0	14.5	0	2.36	0	8.3	0	4.47	0
Cadaval	17.3	0	3.40	1	15.3	0	2.36	1	9.1	0	4.47	2
Caldas da Rainha	3.4	0	3.38	0	3.0	0	2.34	0	0.8	0	4.43	0
Calheta (Açores)	5.0	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Calheta (Madeira)	5.0	0	3.39	1	4.4	0	2.35	0	1.4	0	4.45	1
Câmara de Lobos	5.6	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
Caminha	4.2	0	3.38	0	3.7	0	2.34	0	1.1	0	4.44	0
Campo Maior	5.7	0	3.39	1	5.1	0	2.35	0	1.7	0	4.46	1
Cantanhede	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Carrazeda de Ansiães	5.0	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Carregal do Sal	5.9	0	3.40	0	5.2	0	2.35	0	1.8	0	4.46	1
Cartaxo	20.3	0	3.40	7	18.0	0	2.36	5	11.6	0	4.47	9

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Cascais	5.3	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Castanheira de Pêra	4.6	0	3.39	1	4.1	0	2.35	1	1.2	0	4.45	2
Castelo Branco	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Castelo de Paiva	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Castelo de Vide	4.9	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Castro Daire	4.0	0	3.38	0	3.6	0	2.34	0	1.0	0	4.44	0
Castro Marim	4.7	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Castro Verde	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.44	0
Celorico da Beira	4.9	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Celorico de Basto	5.6	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
Chamusca	4.4	0	3.39	1	3.8	0	2.34	0	1.1	0	4.44	1
Chaves	5.0	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Cinfães	5.5	0	3.39	4	4.9	0	2.35	3	1.6	0	4.46	5
Coimbra	5.6	0	3.39	0	5.0	0	2.35	0	1.7	0	4.46	0
Condeixa-a-Nova	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Constância	5.5	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
Coruche	2.2	0	3.37	0	1.9	0	2.33	0	0.4	0	4.41	0
Corvo	4.6	0	3.39	1	4.1	0	2.35	1	1.2	0	4.45	2
Covilhã	4.7	0	3.39	0	4.1	0	2.35	0	1.3	0	4.45	0
Crato	4.7	0	3.39	0	4.1	0	2.35	0	1.3	0	4.45	0
Cuba	4.2	0	3.38	0	3.7	0	2.34	0	1.1	0	4.44	0
Elvas	5.6	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Entroncamento	5.7	0	3.39	1	5.0	0	2.35	0	1.7	0	4.46	1
Espinho	5.6	0	3.39	1	5.0	0	2.35	0	1.7	0	4.46	1
Esposende	5.6	0	3.39	0	5.0	0	2.35	0	1.7	0	4.46	1
Estarreja	4.6	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Estremoz	4.8	0	3.39	1	4.2	0	2.35	1	1.3	0	4.45	2
Évora	5.0	0	3.39	1	4.4	0	2.35	1	1.4	0	4.45	2
Fafe	4.3	0	3.39	2	3.8	0	2.34	1	1.1	0	4.44	2
Faro	5.1	0	3.39	1	4.5	0	2.35	1	1.4	0	4.45	2
Felgueiras	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Ferreira do Alentejo	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Ferreira do Zêzere	13.2	0	3.40	1	11.7	0	2.35	1	6.1	0	4.46	2
Figueira da Foz	4.1	0	3.38	0	3.6	0	2.34	0	1.0	0	4.44	0
Figueira de Castelo Rodrigo	5.4	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Figueiró dos Vinhos	4.6	0	3.39	0	4.1	0	2.35	0	1.2	0	4.45	0
Fornos de Algodres	4.0	0	3.38	0	3.5	0	2.34	0	1.0	0	4.44	0
Freixo de Espada à Cinta	4.7	0	3.39	0	4.1	0	2.35	0	1.3	0	4.45	0
Fronteira	4.9	0	3.39	3	4.4	0	2.35	2	1.4	0	4.45	4
Fundão	4.6	0	3.39	0	4.1	0	2.35	0	1.2	0	4.45	1
Gavião	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Góis	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Golegã	5.6	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
Gondomar	5.5	0	3.39	5	4.9	0	2.35	3	1.6	0	4.46	7

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Gouveia	4.7	0	3.39	0	4.1	0	2.35	0	1.3	0	4.45	0
Grândola	5.4	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Guarda	4.4	0	3.39	1	3.9	0	2.34	0	1.1	0	4.44	1
Guimarães	5.2	0	3.39	5	4.6	0	2.35	3	1.5	0	4.45	6
Horta	3.1	0	3.38	0	2.7	0	2.34	0	0.7	0	4.42	0
Idanha-a-Nova	4.4	0	3.39	0	3.9	0	2.34	0	1.1	0	4.44	0
Ílhavo	5.8	0	3.40	1	5.1	0	2.35	0	1.7	0	4.46	1
Lagoa (Açores)	4.9	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Lagoa (Faro)	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	1
Lagos	5.0	0	3.39	1	4.4	0	2.35	0	1.4	0	4.45	1
Lajes das Flores	2.2	0	3.37	0	1.9	0	2.33	0	0.4	0	4.41	0
Lajes do Pico	3.9	0	3.38	0	3.5	0	2.34	0	1.0	0	4.44	0
Lamego	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	1
Leiria	12.5	0	3.40	4	11.1	0	2.35	2	5.6	0	4.46	5
Lisboa	15.2	0	3.40	17	13.4	0	2.36	11	7.5	0	4.47	22
Loulé	4.4	0	3.39	2	3.9	0	2.34	1	1.2	0	4.44	3
Loures	16.2	0	3.40	7	14.3	0	2.36	4	8.2	0	4.47	9
Lourinhã	20.3	0	3.40	0	18.0	0	2.36	0	11.6	0	4.47	1
Lousã	5.3	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Lousada	5.2	0	3.39	1	4.6	0	2.35	1	1.5	0	4.45	2
Mação	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Macedo de Cavaleiros	4.0	0	3.38	0	3.6	0	2.34	0	1.0	0	4.44	0

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Machico	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Madalena	3.1	0	3.38	0	2.7	0	2.34	0	0.7	0	4.42	0
Madeira	19.5	0	3.40	2	17.3	0	2.36	1	10.9	0	4.47	3
Mafra	5.6	0	3.39	4	4.9	0	2.35	3	1.6	0	4.46	6
Maia	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Mangualde	4.6	0	3.39	0	4.1	0	2.35	0	1.2	0	4.45	0
Manteigas	5.1	0	3.39	1	4.5	0	2.35	1	1.4	0	4.45	2
Marco de Canaveses	14.3	0	3.40	1	12.7	0	2.35	0	6.8	0	4.47	1
Marinha Grande	4.5	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Marvão	5.7	0	3.39	5	5.0	0	2.35	4	1.7	0	4.46	7
Matosinhos	5.5	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
Mealhada	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Mêda	4.9	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Melgaço	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Mértola	4.8	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Mesão Frio	5.9	0	3.40	0	5.2	0	2.35	0	1.8	0	4.46	0
Mira	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Miranda do Corvo	3.6	0	3.38	0	3.2	0	2.34	0	0.8	0	4.43	0
Miranda do Douro	4.2	0	3.38	0	3.7	0	2.34	0	1.1	0	4.44	0
Mirandela	3.9	0	3.38	0	3.4	0	2.34	0	1.0	0	4.44	0
Mogadouro	4.6	0	3.39	0	4.1	0	2.35	0	1.2	0	4.45	0
Moimenta da Beira	12.9	0	3.40	2	11.4	0	2.35	1	5.8	0	4.46	2

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Moita	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Monção	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Monchique	4.8	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Mondim de Basto	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.44	0
Monforte	4.6	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Montalegre	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Montemor-o-Novo	5.8	0	3.40	0	5.2	0	2.35	0	1.8	0	4.46	1
Montemor-o-Velho	12.8	0	3.40	1	11.4	0	2.35	1	5.8	0	4.46	2
Montijo	5.1	0	3.39	0	4.5	0	2.35	0	1.5	0	4.45	0
Mora	5.3	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Mortágua	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Moura	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Mourão	4.4	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Murça	5.7	0	3.39	0	5.0	0	2.35	0	1.7	0	4.46	0
Murtosa	16.3	0	3.40	0	14.5	0	2.36	0	8.3	0	4.47	0
Nazaré	4.9	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Nelas	4.7	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Nisa	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Nordeste	17.5	0	3.40	0	15.5	0	2.36	0	9.3	0	4.47	0
Óbidos	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	1
Odemira	16.3	0	3.40	5	14.5	0	2.36	3	8.4	0	4.47	7
Odivelas	18.1	0	3.40	5	16.0	0	2.36	4	9.7	0	4.47	7

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Oeiras	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Oleiros	4.2	0	3.39	1	3.7	0	2.34	1	1.1	0	4.44	1
Olhão	5.5	0	3.39	2	4.9	0	2.35	1	1.6	0	4.46	2
Oliveira de Azeméis	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Oliveira de Frades	5.6	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	1
Oliveira do Bairro	4.9	0	3.39	0	4.3	0	2.35	0	1.4	0	4.45	0
Oliveira do Hospital	5.7	0	3.39	1	5.1	0	2.35	1	1.7	0	4.46	1
Ourém	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Ourique	5.7	0	3.39	1	5.0	0	2.35	1	1.7	0	4.46	2
Ovar	5.3	0	3.39	1	4.7	0	2.35	1	1.5	0	4.46	2
Paços de Ferreira	5.9	0	3.40	2	5.2	0	2.35	1	1.8	0	4.46	2
Palmela	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Pampilhosa da Serra	5.3	0	3.39	2	4.6	0	2.35	2	1.5	0	4.45	3
Paredes	5.3	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Paredes de Coura	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Pedrógão Grande	5.4	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Penacova	5.2	0	3.39	2	4.6	0	2.35	1	1.5	0	4.45	3
Penafiel	4.7	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Penalva do Castelo	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Penamacor	4.4	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Penedono	5.5	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Penela	22.0	0	3.40	0	19.6	0	2.36	0	13.1	0	4.47	1

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Peniche	4.7	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Peso da Régua	4.2	0	3.38	0	3.7	0	2.34	0	1.1	0	4.44	0
Pinhel	5.8	0	3.40	1	5.1	0	2.35	1	1.7	0	4.46	2
Pombal	4.9	0	3.39	2	4.3	0	2.35	1	1.3	0	4.45	3
Ponta do Sol	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Ponte da Barca	5.2	0	3.39	0	4.5	0	2.35	0	1.5	0	4.45	0
Ponte de Lima	5.3	0	3.39	1	4.7	0	2.35	0	1.5	0	4.46	1
Ponte de Sôr	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Portalegre	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.44	0
Portel	4.6	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Portimão	4.9	0	3.39	1	4.3	0	2.35	1	1.3	0	4.45	2
Porto	5.6	0	3.39	7	4.9	0	2.35	5	1.6	0	4.46	9
Porto de Mós	12.6	0	3.40	0	11.2	0	2.35	0	5.7	0	4.46	1
Porto Moniz	5.3	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Porto Santo	5.5	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
Póvoa de Lanhoso	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Póvoa de Varzim	5.7	0	3.39	2	5.0	0	2.35	1	1.7	0	4.46	2
Povoação	5.3	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Proença-a-Nova	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Redondo	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.44	0
Reguengos de Monsaraz	4.4	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Resende	4.9	0	3.39	0	4.3	0	2.35	0	1.4	0	4.45	0

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Ribeira Brava	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Ribeira de Pena	4.7	0	3.39	0	4.1	0	2.35	0	1.3	0	4.45	0
Ribeira Grande	5.0	0	3.39	1	4.4	0	2.35	0	1.4	0	4.45	1
Rio Maior	13.9	0	3.40	0	12.4	0	2.35	0	6.6	0	4.47	0
Sabrosa	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Sabugal	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Salvaterra de Magos	5.9	0	3.40	0	5.2	0	2.35	0	1.8	0	4.46	0
Santa Comba Dão	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Santa Cruz	5.0	0	3.39	1	4.4	0	2.35	1	1.4	0	4.45	1
Santa Cruz da Graciosa	3.4	0	3.38	0	3.0	0	2.34	0	0.8	0	4.43	0
Santa Cruz das Flores	2.2	0	3.37	0	1.9	0	2.33	0	0.4	0	4.41	0
Santa Maria da Feira	5.6	0	3.39	4	4.9	0	2.35	3	1.6	0	4.46	6
Santa Marta de Penaguião	4.7	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Santana	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Santarém	5.8	0	3.40	1	5.1	0	2.35	1	1.7	0	4.46	2
Santiago do Cacém	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	1
Santo Tirso	5.4	0	3.39	2	4.7	0	2.35	1	1.6	0	4.46	3
São Brás de Alportel	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
São João da Madeira	5.5	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
São João da Pesqueira	4.4	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
São Pedro do Sul	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
São Roque do Pico	4.9	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
São Vicente	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Sardoal	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Sátão	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Seia	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Seixal	14.4	0	3.40	5	12.8	0	2.35	3	6.9	0	4.47	7
Sernancelhe	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Serpa	4.4	0	3.39	0	3.9	0	2.34	0	1.1	0	4.44	0
Sertã	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Sesimbra	13.6	0	3.40	1	12.0	0	2.35	1	6.3	0	4.47	2
Setúbal	5.9	0	3.40	3	5.2	0	2.35	2	1.8	0	4.46	5
Sever do Vouga	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Silves	4.8	0	3.39	1	4.2	0	2.35	0	1.3	0	4.45	1
Sines	5.6	0	3.39	0	5.0	0	2.35	0	1.7	0	4.46	0
Sintra	19.9	0	3.40	13	17.7	0	2.36	9	11.3	0	4.47	17
Sobral de Monte Agraço	16.5	0	3.40	0	14.6	0	2.36	0	8.5	0	4.47	0
Soure	5.8	0	3.40	0	5.1	0	2.35	0	1.7	0	4.46	0
Sousel	4.7	0	3.39	0	4.1	0	2.35	0	1.3	0	4.45	0
Tábua	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Tabuaço	4.6	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Tarouca	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Tavira	4.1	0	3.38	0	3.7	0	2.34	0	1.0	0	4.44	1
Terras de Bouro	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Tomar	5.5	0	3.39	1	4.9	0	2.35	0	1.6	0	4.46	1
Tondela	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	1
Torre de Moncorvo	4.2	0	3.38	0	3.7	0	2.34	0	1.0	0	4.44	0
Torres Novas	5.7	0	3.39	1	5.0	0	2.35	0	1.7	0	4.46	1
Torres Vedras	18.7	0	3.40	2	16.6	0	2.36	1	10.3	0	4.47	3
Trancoso	4.4	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Trofa	5.5	0	3.39	1	4.8	0	2.35	0	1.6	0	4.46	1
Vagos	5.8	0	3.40	0	5.1	0	2.35	0	1.7	0	4.46	1
Vale de Cambra	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Valença	5.3	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Valongo	5.5	0	3.39	3	4.8	0	2.35	2	1.6	0	4.46	4
Valpaços	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Velas	3.3	0	3.38	0	2.9	0	2.34	0	0.7	0	4.43	0
Vendas Novas	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Viana do Alentejo	4.8	0	3.39	0	4.3	0	2.35	0	1.3	0	4.45	0
Viana do Castelo	5.6	0	3.39	2	5.0	0	2.35	1	1.7	0	4.46	3
Vidigueira	4.6	0	3.39	0	4.1	0	2.35	0	1.2	0	4.45	0
Vieira do Minho	4.9	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Vila da Praia da Vitória	4.0	0	3.38	0	3.5	0	2.34	0	1.0	0	4.44	0
Vila de Rei	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Vila do Bispo	5.2	0	3.39	0	4.6	0	2.35	0	1.5	0	4.45	0
Vila do Conde	5.7	0	3.39	2	5.0	0	2.35	1	1.7	0	4.46	3

Table D.1.3: Apophis' seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-14}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-13}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-17}]$	C_p	V_p $[10^{-5}]$	C_p
Vila do Porto	5.0	0	3.39	0	4.4	0	2.35	0	1.4	0	4.45	0
Vila Flor	4.2	0	3.38	0	3.7	0	2.34	0	1.1	0	4.44	0
Vila Franca de Xira	13.8	0	3.40	4	12.2	0	2.35	3	6.5	0	4.47	6
Vila Franca do Campo	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0
Vila Nova da Barquinha	5.5	0	3.39	0	4.9	0	2.35	0	1.6	0	4.46	0
Vila Nova de Cerveira	5.4	0	3.39	0	4.8	0	2.35	0	1.6	0	4.46	0
Vila Nova de Famalicão	5.4	0	3.39	4	4.8	0	2.35	3	1.6	0	4.46	5
Vila Nova de Foz Côa	4.3	0	3.39	0	3.8	0	2.34	0	1.1	0	4.44	0
Vila Nova de Gaia	5.6	0	3.39	10	4.9	0	2.35	7	1.6	0	4.46	13
Vila Nova de Paiva	4.7	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Vila Nova de Poiares	5.3	0	3.39	0	4.7	0	2.35	0	1.5	0	4.46	0
Vila Pouca de Aguiar	4.5	0	3.39	0	4.0	0	2.35	0	1.2	0	4.45	0
Vila Real	4.7	0	3.39	1	4.1	0	2.35	1	1.3	0	4.45	2
Vila Real de Santo António	4.0	0	3.38	0	3.5	0	2.34	0	1.0	0	4.44	0
Vila Velha de Ródão	4.8	0	3.39	0	4.2	0	2.35	0	1.3	0	4.45	0
Vila Verde	5.2	0	3.39	1	4.6	0	2.35	1	1.5	0	4.45	2
Vila Viçosa	4.4	0	3.39	0	3.9	0	2.34	0	1.2	0	4.44	0
Vimioso	3.7	0	3.38	0	3.3	0	2.34	0	0.9	0	4.43	0
Vinhais	4.0	0	3.38	0	3.5	0	2.34	0	1.0	0	4.44	0
Viseu	4.9	0	3.39	3	4.4	0	2.35	2	1.4	0	4.45	4
Vizela	5.1	0	3.39	0	4.5	0	2.35	0	1.5	0	4.45	1
Vouzela	5.1	0	3.39	0	4.5	0	2.35	0	1.4	0	4.45	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Abrantes	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Açores	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Águeda	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Aguiar da Beira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alandroal	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Albergaria-a-Velha	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Albufeira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alcácer do Sal	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alcanena	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alcobaça	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alcochete	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alcoutim	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alenquer	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alfândega da Fé	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alijó	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Aljezur	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Aljustrel	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Almada	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Almeida	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Almeirim	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Almodôvar	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alpiarça	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Alter do Chão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alvaiázere	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Alvito	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Amadora	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Amarante	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Amares	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Anadia	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Angra do Heroísmo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ansião	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Arcos de Valdevez	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Arganil	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Armamar	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Arouca	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Arraiolos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Arronches	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Arruda dos Vinhos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Aveiro	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Avis	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Azambuja	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Baião	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Barcelos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Barrancos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Barreiro	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Batalha	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Beja	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Belmonte	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Benavente	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Bombarral	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Borba	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Boticas	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Braga	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Bragança	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Cabeceiras de Basto	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Cadaval	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Caldas da Rainha	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Calheta (Açores)	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Calheta (Madeira)	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Câmara de Lobos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Caminha	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Campo Maior	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Cantanhede	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Carrazeda de Ansiães	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Carregal do Sal	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Cartaxo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Cascais	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Castanheira de Pêra	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Castelo Branco	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Castelo de Paiva	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Castelo de Vide	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Castro Daire	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Castro Marim	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Castro Verde	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Celorico da Beira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Celorico de Basto	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Chamusca	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Chaves	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Cinfães	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Coimbra	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Condeixa-a-Nova	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Constância	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Coruche	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Corvo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Covilhã	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Crato	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Cuba	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Elvas	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Entroncamento	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Espinho	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Esposende	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Estarreja	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Estremoz	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Évora	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Fafe	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Faro	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Felgueiras	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ferreira do Alentejo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ferreira do Zêzere	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Figueira da Foz	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Figueira de Castelo Rodrigo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Figueiró dos Vinhos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Fornos de Algodres	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Freixo de Espada à Cinta	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Fronteira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Fundão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Gavião	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Góis	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Golegã	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Gondomar	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Gouveia	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Grândola	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Guarda	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Guimarães	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Horta	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Idanha-a-Nova	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ílhavo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lagoa (Açores)	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lagoa (Faro)	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lagos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lajes das Flores	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lajes do Pico	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lamego	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Leiria	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lisboa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Loulé	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Loures	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lourinhã	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lousã	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Lousada	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mação	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Macedo de Cavaleiros	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Machico	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Madalena	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Madeira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mafra	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Maia	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mangualde	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Manteigas	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Marco de Canaveses	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Marinha Grande	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Marvão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Matosinhos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mealhada	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mêda	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Melgaço	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mértola	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mesão Frio	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Miranda do Corvo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Miranda do Douro	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mirandela	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mogadouro	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Moimenta da Beira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Moita	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Monção	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Monchique	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mondim de Basto	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Monforte	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Montalegre	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Montemor-o-Novo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Montemor-o-Velho	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Montijo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mora	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mortágua	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Moura	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Mourão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Murça	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Murtosa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Nazaré	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Nelas	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Nisa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Nordeste	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Óbidos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Odemira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Odivelas	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Oeiras	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Oleiros	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Olhão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Oliveira de Azeméis	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Oliveira de Frades	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Oliveira do Bairro	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Oliveira do Hospital	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ourém	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ourique	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ovar	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Paços de Ferreira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Palmela	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Pampilhosa da Serra	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Paredes	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Paredes de Coura	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Pedrógão Grande	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Penacova	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Penafiel	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Penalva do Castelo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Penamacor	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Penedono	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Penela	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Peniche	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Peso da Régua	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Pinhel	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Pombal	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ponta do Sol	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ponte da Barca	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ponte de Lima	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ponte de Sôr	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Portalegre	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Portel	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Portimão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Porto	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Porto de Mós	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Porto Moniz	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Porto Santo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Póvoa de Lanhoso	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Póvoa de Varzim	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Povoação	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Proença-a-Nova	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Redondo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Reguengos de Monsaraz	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Resende	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Ribeira Brava	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ribeira de Pena	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Ribeira Grande	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Rio Maior	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sabrosa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sabugal	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Salvaterra de Magos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santa Comba Dão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santa Cruz	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santa Cruz da Graciosa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santa Cruz das Flores	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santa Maria da Feira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santa Marta de Penaguião	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santana	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santarém	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santiago do Cacém	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Santo Tirso	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
São Brás de Alportel	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
São João da Madeira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
São João da Pesqueira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
São Pedro do Sul	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
São Roque do Pico	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
São Vicente	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sardoal	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sátão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Seia	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Seixal	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sernancelhe	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Serpa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sertã	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sesimbra	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Setúbal	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sever do Vouga	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Silves	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sines	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sintra	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sobral de Monte Agraço	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Soure	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Sousel	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Tábua	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Tabuaço	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Tarouca	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Tavira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Terras de Bouro	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e [10^{-8}]	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e [10^{-10}]	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e [10^{-14}]	C_e
Tomar	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Tondela	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Torre de Moncorvo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Torres Novas	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Torres Vedras	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Trancoso	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Trofa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vagos	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vale de Cambra	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Valença	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Valongo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Valpaços	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Velas	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vendas Novas	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Viana do Alentejo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Viana do Castelo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vidigueira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vieira do Minho	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila da Praia da Vitória	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila de Rei	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila do Bispo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila do Conde	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.4: Apophis' thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Vila do Porto	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Flor	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Franca de Xira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Franca do Campo	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Nova da Barquinha	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Nova de Cerveira	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Nova de Famalicão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Nova de Foz Côa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Nova de Gaia	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Nova de Paiva	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Nova de Poiares	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Pouca de Aguiar	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Real	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Real de Santo António	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Velha de Ródão	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Verde	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vila Viçosa	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vimioso	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vinhais	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Viseu	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vizela	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0
Vouzela	0.00	0	0.00	0	2.21	0	0.00	0	0.00	0	1.87	0	0.00	0	0.00	0	2.60	0

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
1	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
2	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
3	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
4	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
5	0.026	621	0.095	2286	0.234	5650	0.020	492	0.075	1813	0.193	4651	0.004	104	0.015	368	0.045	1089
6	0.059	2409	0.164	6739	0.320	13178	0.042	1730	0.123	5063	0.258	10623	0.004	181	0.015	633	0.045	1863
7	0.168	1969	0.390	4570	0.590	6904	0.109	1279	0.283	3309	0.479	5610	0.005	53	0.016	187	0.047	550
8	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
9	0.067	3579	0.253	13577	0.510	27338	0.047	2534	0.185	9898	0.410	21970	0.005	241	0.016	851	0.047	2520
10	0.281	5480	0.434	8460	0.551	10753	0.179	3489	0.315	6151	0.445	8684	0.005	92	0.016	316	0.047	917
11	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
12	0.007	287	0.034	1479	0.118	5135	0.006	241	0.028	1206	0.097	4220	0.000	0	0.000	0	0.000	0
13	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
14	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
15	0.137	767	0.387	2168	0.624	3491	0.090	506	0.280	1569	0.510	2856	0.005	25	0.016	89	0.047	263
16	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
17	0.404	68339	0.595	100589	0.708	119631	0.261	44062	0.449	75804	0.592	100047	0.005	814	0.017	2802	0.048	8125
18	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
19	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
20	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
21	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
22	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
23	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
24	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
25	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
26	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
27	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
28	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
29	0.999	33867	1.000	33902	1.000	33902	0.995	33731	1.000	33902	1.000	33902	0.006	187	0.021	728	0.066	2235
30	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
31	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
32	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
33	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
34	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
35	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
36	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
37	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
38	0.059	4634	0.139	10795	0.253	19719	0.043	3323	0.106	8234	0.207	16132	0.004	347	0.015	1203	0.045	3525
39	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
40	0.006	128	0.021	480	0.064	1436	0.005	109	0.018	415	0.056	1266	0.000	0	0.000	0	0.000	0
41	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
42	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
43	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
44	0.286	21590	0.448	33805	0.570	43012	0.182	13747	0.327	24628	0.462	34838	0.005	357	0.016	1226	0.047	3558

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
45	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
46	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
47	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
48	0.275	8303	0.437	13207	0.562	16976	0.175	5288	0.318	9607	0.454	13731	0.005	142	0.016	489	0.047	1420
49	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
50	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
51	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
52	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
53	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
54	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
55	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
56	0.167	8599	0.389	20025	0.588	30318	0.108	5590	0.281	14499	0.478	24631	0.005	239	0.016	835	0.047	2445
57	1.000	3204	1.000	3205	1.000	3205	1.000	3204	1.000	3204	1.000	3205	0.008	27	0.037	119	0.116	370
58	1.000	10864	1.000	10865	1.000	10865	1.000	10864	1.000	10865	1.000	10865	0.013	137	0.091	988	0.317	3444
59	1.000	33731	1.000	33732	1.000	33732	1.000	33731	1.000	33732	1.000	33732	0.010	344	0.071	2408	0.260	8773
60	0.092	1459	0.452	7172	0.775	12307	0.063	998	0.329	5227	0.664	10537	0.005	71	0.016	257	0.048	767
61	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
62	0.026	898	0.073	2559	0.162	5688	0.020	712	0.060	2090	0.138	4845	0.004	152	0.015	530	0.045	1562
63	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
64	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
65	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
66	0.585	124192	0.892	189589	0.960	204028	0.400	84906	0.786	166987	0.915	194420	0.005	1054	0.018	3741	0.052	11014

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
67	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
68	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
69	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
70	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
71	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
72	0.019	117	0.062	385	0.152	953	0.015	96	0.051	321	0.130	818	0.004	26	0.015	93	0.044	276
73	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
74	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
75	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
76	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
77	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
78	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
79	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
80	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
81	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
82	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
83	1.000	64	1.000	64	1.000	64	1.000	64	1.000	64	1.000	64	0.007	0	0.027	1	0.082	5
84	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
85	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
86	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
87	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
88	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
89	0.036	1069	0.095	2790	0.194	5708	0.028	812	0.075	2213	0.162	4778	0.004	129	0.015	449	0.045	1320
90	0.147	5014	0.367	12486	0.576	19618	0.097	3289	0.265	9031	0.467	15904	0.005	156	0.016	545	0.047	1601
91	0.034	881	0.092	2397	0.194	5036	0.026	675	0.073	1907	0.162	4214	0.004	113	0.015	395	0.045	1163
92	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
93	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
94	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
95	0.051	3082	0.177	10822	0.380	23153	0.037	2251	0.132	8076	0.304	18551	0.004	267	0.015	939	0.046	2776
96	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
97	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
98	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
99	0.029	1678	0.090	5274	0.205	12066	0.022	1312	0.072	4209	0.171	10046	0.004	257	0.015	899	0.045	2650
100	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
101	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
102	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
103	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
104	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
105	1.000	104128	1.000	104129	1.000	104129	1.000	104128	1.000	104129	1.000	104129	0.012	1293	0.097	10114	0.346	36002
106	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
107	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
108	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
109	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
110	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
111	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
112	0.119	1735	0.330	4811	0.553	8057	0.080	1158	0.239	3479	0.447	6509	0.005	66	0.016	231	0.047	681
113	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
114	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
115	0.874	12711	0.998	14508	1.000	14538	0.728	10586	0.991	14416	0.999	14528	0.005	69	0.018	259	0.054	786
116	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
117	0.066	2543	0.148	5676	0.262	10044	0.047	1802	0.112	4303	0.213	8197	0.004	172	0.015	594	0.045	1740
118	0.994	14594	1.000	14680	1.000	14680	0.977	14348	1.000	14676	1.000	14680	0.005	80	0.021	309	0.064	942
119	0.127	2884	0.259	5897	0.404	9189	0.084	1915	0.189	4295	0.323	7355	0.005	103	0.016	356	0.046	1041
120	0.053	1627	0.157	4767	0.316	9609	0.039	1181	0.118	3595	0.255	7752	0.004	134	0.015	469	0.045	1382
121	1.000	1463	1.000	1463	1.000	1463	1.000	1463	1.000	1463	1.000	1463	0.006	8	0.024	34	0.071	104
122	1.000	4497	1.000	4498	1.000	4498	1.000	4497	1.000	4498	1.000	4498	0.008	35	0.053	236	0.200	898
123	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
124	0.062	7695	0.212	26481	0.432	53876	0.044	5495	0.156	19504	0.345	43114	0.004	559	0.016	1964	0.046	5799
125	0.291	147516	0.544	276155	0.709	359744	0.185	93928	0.404	205109	0.593	300975	0.005	2408	0.016	8359	0.048	24402
126	0.067	4635	0.280	19283	0.563	38799	0.048	3278	0.203	13999	0.456	31391	0.004	305	0.016	1078	0.046	3199
127	0.295	62282	0.653	138114	0.834	176320	0.188	39658	0.503	106221	0.733	154896	0.005	1005	0.017	3537	0.049	10405
128	0.030	774	0.089	2295	0.198	5083	0.023	601	0.071	1832	0.165	4245	0.004	113	0.015	393	0.045	1157
129	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
130	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
131	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
132	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
133	1.000	20093	1.000	20093	1.000	20094	1.000	20093	1.000	20093	1.000	20094	0.008	160	0.041	825	0.139	2798
134	0.998	5862	1.000	5874	1.000	5874	0.990	5819	1.000	5874	1.000	5874	0.005	30	0.024	140	0.080	471
135	0.037	3071	0.134	11259	0.310	26076	0.028	2330	0.103	8615	0.251	21055	0.004	371	0.016	1306	0.046	3861
136	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
137	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
138	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
139	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
140	0.074	2838	0.184	7076	0.334	12819	0.052	1987	0.137	5265	0.269	10315	0.005	173	0.016	601	0.046	1762
141	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
142	0.054	9331	0.136	23710	0.261	45492	0.039	6771	0.104	18118	0.213	37136	0.004	775	0.015	2691	0.045	7897
143	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
144	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
145	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
146	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
147	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
148	0.027	315	0.071	835	0.151	1786	0.021	248	0.058	685	0.130	1533	0.004	51	0.015	179	0.044	526
149	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
150	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
151	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
152	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
153	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
154	0.281	18143	0.432	27890	0.549	35400	0.179	11553	0.314	20276	0.443	28580	0.005	305	0.016	1046	0.047	3033

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
155	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
156	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
157	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
158	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
159	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
160	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
161	0.007	187	0.026	650	0.072	1826	0.006	154	0.022	548	0.063	1586	0.000	0	0.000	0	0.000	0
162	0.281	15987	0.478	27170	0.620	35295	0.179	10180	0.350	19888	0.507	28856	0.005	268	0.016	927	0.047	2698
163	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
164	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
165	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
166	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
167	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
168	0.069	710	0.145	1483	0.248	2539	0.049	500	0.110	1126	0.203	2080	0.004	45	0.015	158	0.045	462
169	0.684	9700	0.833	11807	0.888	12590	0.492	6979	0.702	9953	0.803	11385	0.005	70	0.017	244	0.050	706
170	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
171	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
172	0.998	4866	1.000	4874	1.000	4874	0.992	4837	1.000	4874	1.000	4874	0.006	28	0.023	112	0.072	350
173	0.415	4858	0.665	7792	0.793	9289	0.268	3139	0.514	6020	0.683	8009	0.005	56	0.017	196	0.049	572
174	0.061	1500	0.236	5818	0.489	12048	0.044	1073	0.173	4257	0.393	9666	0.004	109	0.016	386	0.046	1143
175	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
176	0.517	91186	0.734	129331	0.831	146414	0.344	60691	0.585	103022	0.729	128416	0.005	864	0.017	2988	0.049	8677

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
177	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
178	0.026	1147	0.093	4169	0.230	10254	0.020	909	0.074	3312	0.190	8453	0.004	192	0.015	674	0.045	1995
179	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
180	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
181	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
182	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
183	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
184	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
185	0.043	2350	0.126	6836	0.263	14239	0.032	1747	0.097	5261	0.215	11616	0.004	239	0.015	833	0.045	2453
186	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
187	0.306	19660	0.657	42156	0.832	53432	0.195	12522	0.506	32460	0.730	46892	0.005	304	0.017	1068	0.049	3141
188	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
189	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
190	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
191	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
192	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
193	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
194	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
195	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
196	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
197	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
198	0.963	25497	0.979	25938	0.983	26024	0.894	23668	0.944	24996	0.957	25359	0.005	144	0.019	493	0.053	1409

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
199	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
200	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
201	0.034	1731	0.140	7219	0.341	17615	0.026	1328	0.106	5502	0.274	14161	0.004	226	0.015	800	0.046	2372
202	0.973	66009	0.999	67827	1.000	67859	0.918	62268	0.998	67698	1.000	67842	0.005	356	0.020	1336	0.059	4036
203	1.000	8543	1.000	8544	1.000	8544	1.000	8543	1.000	8544	1.000	8544	0.009	78	0.054	465	0.191	1633
204	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
205	0.008	340	0.060	2491	0.232	9630	0.006	262	0.044	1811	0.174	7202	0.000	0	0.000	0	0.000	0
206	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
207	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
208	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
209	0.065	3582	0.200	11101	0.395	21889	0.046	2545	0.148	8209	0.316	17525	0.004	246	0.016	861	0.046	2538
210	0.045	9613	0.120	25826	0.241	51988	0.033	7124	0.093	19980	0.198	42686	0.004	951	0.015	3307	0.045	9718
211	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
212	1.000	2349	1.000	2350	1.000	2350	1.000	2349	1.000	2350	1.000	2350	0.010	23	0.064	149	0.225	529
213	1.000	5175	1.000	5175	1.000	5175	1.000	5175	1.000	5175	1.000	5175	0.007	38	0.028	142	0.080	414
214	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
215	0.195	12188	0.406	25360	0.585	36573	0.126	7849	0.294	18385	0.475	29697	0.005	290	0.016	1006	0.047	2943
216	1.000	5953	1.000	5953	1.000	5953	1.000	5953	1.000	5953	1.000	5953	0.008	47	0.037	218	0.117	697
217	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
218	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
219	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
220	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
221	1.000	12410	1.000	12411	1.000	12411	1.000	12410	1.000	12411	1.000	12411	0.010	126	0.067	836	0.241	2992
222	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
223	1.000	32696	1.000	32697	1.000	32697	1.000	32687	1.000	32697	1.000	32697	0.006	206	0.025	813	0.076	2482
224	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
225	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
226	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
227	0.008	173	0.028	586	0.076	1607	0.007	141	0.023	490	0.065	1389	0.000	0	0.000	0	0.000	0
228	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
229	1.000	44743	1.000	44744	1.000	44744	1.000	44743	1.000	44744	1.000	44744	0.011	470	0.061	2731	0.208	9309
230	1.000	4223	1.000	4224	1.000	4224	0.998	4214	1.000	4223	1.000	4224	0.006	23	0.020	82	0.057	240
231	1.000	2163	1.000	2163	1.000	2164	1.000	2163	1.000	2163	1.000	2163	0.007	15	0.029	62	0.089	192
232	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
233	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
234	1.000	6749	1.000	6749	1.000	6750	1.000	6749	1.000	6749	1.000	6749	0.007	45	0.035	235	0.121	817
235	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
236	0.121	3466	0.352	10115	0.589	16923	0.080	2311	0.255	7314	0.479	13751	0.005	130	0.016	458	0.047	1350
237	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
238	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
239	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
240	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
241	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
242	1.000	3263	1.000	3264	1.000	3264	1.000	3263	1.000	3264	1.000	3264	0.008	27	0.060	197	0.232	756

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
243	1.000	5149	1.000	5150	1.000	5150	1.000	5149	1.000	5150	1.000	5150	0.009	45	0.052	269	0.186	957
244	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
245	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
246	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
247	0.288	47993	0.453	75526	0.576	96146	0.183	30558	0.330	55059	0.467	77951	0.005	790	0.016	2715	0.047	7879
248	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
249	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
250	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
251	1.000	51544	1.000	51556	1.000	51557	0.998	51473	1.000	51543	1.000	51550	0.006	320	0.022	1133	0.063	3264
252	0.305	35360	0.714	82621	0.884	102347	0.195	22522	0.563	65184	0.798	92344	0.005	548	0.017	1941	0.050	5735
253	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
254	0.108	3911	0.346	12502	0.598	21639	0.073	2634	0.250	9040	0.487	17613	0.005	163	0.016	573	0.047	1692
255	0.099	1353	0.261	3552	0.452	6167	0.067	918	0.190	2586	0.362	4937	0.005	61	0.016	215	0.046	632
256	0.158	61327	0.507	197009	0.765	297157	0.103	40023	0.373	145048	0.652	253411	0.005	1808	0.016	6408	0.049	18959
257	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
258	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
259	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
260	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
261	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
262	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
263	0.043	1062	0.175	4333	0.401	9924	0.032	791	0.131	3237	0.321	7944	0.004	108	0.015	380	0.046	1128
264	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
265	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
266	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
267	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
268	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
269	0.031	2395	0.109	8529	0.259	20229	0.024	1857	0.085	6664	0.211	16523	0.004	344	0.015	1207	0.046	3566
270	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
271	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
272	0.057	1295	0.132	3004	0.243	5508	0.041	933	0.101	2301	0.199	4521	0.004	101	0.015	350	0.045	1025
273	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
274	0.032	421	0.163	2159	0.418	5547	0.024	325	0.122	1623	0.334	4439	0.004	58	0.016	206	0.046	613
275	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
276	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
277	1.000	5136	1.000	5137	1.000	5137	1.000	5136	1.000	5137	1.000	5137	0.009	48	0.044	228	0.141	726
278	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
279	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
280	0.161	13592	0.656	55508	0.897	75899	0.105	8859	0.505	42730	0.815	69008	0.005	389	0.017	1405	0.050	4199
281	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
282	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
283	0.496	10584	0.936	19965	0.987	21057	0.328	6993	0.858	18294	0.967	20633	0.005	100	0.017	362	0.051	1084
284	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
285	0.958	4939	0.976	5031	0.980	5049	0.884	4556	0.937	4827	0.952	4904	0.005	26	0.018	92	0.051	265
286	0.100	7966	0.257	20483	0.444	35346	0.068	5406	0.188	14922	0.356	28292	0.005	361	0.016	1256	0.046	3688

Table D.1.5: Apophis' tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
287	1.000	5622	1.000	5622	1.000	5622	1.000	5622	1.000	5622	1.000	5622	0.008	46	0.031	176	0.092	516
288	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
289	0.285	40394	0.625	88535	0.810	114676	0.182	25720	0.476	67388	0.703	99609	0.005	670	0.017	2354	0.049	6918
290	1.000	11077	1.000	11077	1.000	11077	1.000	11076	1.000	11077	1.000	11077	0.006	71	0.026	291	0.081	897
291	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
292	0.048	422	0.214	1896	0.481	4271	0.035	310	0.157	1395	0.386	3424	0.004	39	0.016	139	0.047	413
293	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
294	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
295	0.039	11559	0.118	35468	0.256	76789	0.029	8717	0.092	27481	0.209	62770	0.004	1320	0.015	4608	0.045	13577
296	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
297	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
298	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
299	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
300	0.019	357	0.060	1133	0.145	2744	0.016	294	0.050	947	0.125	2365	0.004	80	0.015	281	0.044	832
301	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
302	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
303	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
304	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
305	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
306	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
307	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
308	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

D.2 Medium Asteroid's impact effects

Table D.2.1 shows Medium Asteroid's impact effects results. This includes the seismic shaking, the overpressure, the thermal radiation and the ejecta results. Along with the variables related to each impact effect, the distance to the impact site, the population and the ID for each municipality are also repeated.

Table D.2.2 shows Medium Asteroid's tsunami effects simulations. Besides the rim-wave and collapse wave variables, the minimum and maximum altitudes for each municipality are also repeated.

Table D.2.3 shows Medium Asteroid-induced seismic shaking and overpressure vulnerabilities and casualties for all three case scenarios.

Table D.2.4 shows Medium Asteroid-induced thermal radiation and ejecta deposit vulnerabilities and casualties for all three case scenarios.

Table D.2.5 shows Medium Asteroid-induced tsunami vulnerabilities and casualties for all three case scenarios. This table, instead of listing the municipalities, lists the ID previously associated to each municipality, for space-saving purposes.

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Abrantes	1	35377	750.5	−7.1	12.97	428	23.7	0.0	0.0	0.0	133	8.0
Águeda	2	45992	731.3	−7.1	12.64	440	22.5	0.0	0.0	0.0	143	8.6
Aguiar da Beira	3	4740	809.5	−7.2	14.00	396	27.6	0.0	0.0	0.0	109	6.4
Alandroal	4	5064	829.3	−7.2	14.34	386	28.9	0.0	0.0	0.0	102	5.9
Albergaria-a-Velha	5	24128	729.7	−7.1	12.62	441	22.4	0.0	0.0	0.0	143	8.7
Albufeira	6	41123	808.8	−7.2	13.98	396	27.5	0.0	0.0	0.0	109	6.4
Alcácer do Sal	7	11712	742.0	−7.1	12.83	433	23.2	0.0	0.0	0.0	137	8.3
Alcanena	8	12860	710.4	−7.1	12.28	453	21.2	0.0	0.0	0.0	154	9.4
Alcobaça	9	53641	683.3	−6.7	11.81	471	19.6	0.0	0.0	0.0	171	10.6
Alcochete	10	19505	695.2	−6.8	12.02	463	20.3	0.0	0.0	0.0	163	10.0
Alcoutim	11	2244	857.8	−7.2	14.83	373	30.9	0.0	0.0	0.0	93	5.4
Alenquer	12	43596	685.9	−6.7	11.86	470	19.8	0.0	0.0	0.0	169	10.5
Alfândega da Fé	13	4568	866.1	−7.2	14.97	370	31.5	0.0	0.0	0.0	91	5.2
Alijó	14	10703	822.5	−7.2	14.22	390	28.4	0.0	0.0	0.0	104	6.1
Aljezur	15	5599	753.8	−7.1	13.03	426	23.9	0.0	0.0	0.0	132	7.9
Aljustrel	16	8285	785.9	−7.2	13.59	408	26.0	0.0	0.0	0.0	118	7.0
Almada	17	168987	680.1	−6.7	11.76	474	19.5	0.0	0.0	0.0	173	10.7
Almeida	18	5926	862.0	−7.2	14.90	371	31.2	0.0	0.0	0.0	92	5.3
Almeirim	19	22569	717.4	−7.1	12.40	448	21.6	0.0	0.0	0.0	150	9.1
Almodôvar	20	6746	807.4	−7.2	13.96	397	27.4	0.0	0.0	0.0	110	6.4
Alpiarça	21	7087	719.8	−7.1	12.44	447	21.8	0.0	0.0	0.0	149	9.1
Alter do Chão	22	3191	799.6	−7.2	13.82	401	26.9	0.0	0.0	0.0	113	6.6
Alvaiázere	23	6626	733.3	−7.1	12.68	438	22.6	0.0	0.0	0.0	141	8.6

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Alvito	24	2462	789.4	-7.2	13.65	406	26.2	0.0	0.0	0.0	116	6.9
Amadora	25	181724	671.4	-6.7	11.61	480	19.0	0.0	0.0	0.0	179	11.2
Amarante	26	53366	772.5	-7.2	13.36	416	25.1	0.0	0.0	0.0	123	7.3
Amares	27	18114	759.3	-7.1	13.13	423	24.2	0.0	0.0	0.0	129	7.7
Anadia	28	27298	730.8	-7.1	12.64	440	22.5	0.0	0.0	0.0	143	8.7
Angra do Heroísmo	29	33903	891.2	-7.3	15.41	359	33.4	0.0	0.0	0.0	84	4.8
Ansião	30	12106	728.5	-7.1	12.59	441	22.3	0.0	0.0	0.0	144	8.7
Arcos de Valdevez	31	20970	760.9	-7.1	13.16	422	24.3	0.0	0.0	0.0	128	7.7
Arganil	32	11068	761.6	-7.1	13.17	422	24.4	0.0	0.0	0.0	128	7.6
Armamar	33	5792	801.6	-7.2	13.86	400	27.0	0.0	0.0	0.0	112	6.6
Arouca	34	20861	752.7	-7.1	13.01	427	23.8	0.0	0.0	0.0	132	7.9
Arraiolos	35	6944	779.2	-7.2	13.47	412	25.5	0.0	0.0	0.0	120	7.1
Arronches	36	2860	832.4	-7.2	14.39	385	29.1	0.0	0.0	0.0	101	5.9
Arruda dos Vinhos	37	15082	681.1	-6.7	11.78	473	19.5	0.0	0.0	0.0	172	10.7
Aveiro	38	77916	715.2	-7.1	12.36	450	21.5	0.0	0.0	0.0	151	9.2
Avis	39	4249	781.5	-7.2	13.51	411	25.7	0.0	0.0	0.0	120	7.1
Azambuja	40	22445	697.7	-6.8	12.06	461	20.5	0.0	0.0	0.0	161	9.9
Baião	41	18891	774.2	-7.2	13.39	415	25.2	0.0	0.0	0.0	123	7.3
Barcelos	42	116531	735.5	-7.1	12.72	437	22.8	0.0	0.0	0.0	140	8.5
Barrancos	43	1645	878.8	-7.2	15.19	364	32.5	0.0	0.0	0.0	88	5.0
Barreiro	44	75419	687.7	-6.7	11.89	468	19.9	0.0	0.0	0.0	168	10.4
Batalha	45	15840	695.8	-6.8	12.03	463	20.4	0.0	0.0	0.0	163	10.0
Beja	46	33550	807.1	-7.2	13.95	397	27.4	0.0	0.0	0.0	110	6.4

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Belmonte	47	6407	822.0	−7.2	14.21	390	28.4	0.0	0.0	0.0	105	6.1
Benavente	48	30214	704.3	−7.1	12.18	457	20.9	0.0	0.0	0.0	157	9.7
Bombarral	49	12533	670.3	−6.7	11.59	481	18.9	0.0	0.0	0.0	180	11.2
Borba	50	6790	822.9	−7.2	14.23	389	28.5	0.0	0.0	0.0	104	6.1
Boticas	51	5059	816.2	−7.2	14.11	393	28.0	0.0	0.0	0.0	107	6.2
Braga	52	181919	751.6	−7.1	12.99	427	23.8	0.0	0.0	0.0	133	8.0
Bragança	53	33586	892.5	−7.3	15.43	358	33.5	0.0	0.0	0.0	84	4.7
Cabeceiras de Basto	54	15699	785.6	−7.2	13.58	408	25.9	0.0	0.0	0.0	118	7.0
Cadaval	55	13627	675.3	−6.7	11.67	477	19.2	0.0	0.0	0.0	176	11.0
Caldas da Rainha	56	51540	670.6	−6.7	11.59	481	18.9	0.0	0.0	0.0	179	11.2
Calheta (Açores)	57	3205	960.7	−7.3	16.61	332	38.8	0.0	0.0	0.0	69	3.8
Calheta (Madeira)	58	10865	767.6	−7.2	13.27	418	24.8	0.0	0.0	0.0	125	7.5
Câmara de Lobos	59	33732	773.5	−7.2	13.37	415	25.2	0.0	0.0	0.0	123	7.3
Caminha	60	15873	727.9	−7.1	12.59	442	22.3	0.0	0.0	0.0	144	8.8
Campo Maior	61	7907	852.8	−7.2	14.74	375	30.6	0.0	0.0	0.0	95	5.4
Cantanhede	62	35068	716.5	−7.1	12.39	449	21.6	0.0	0.0	0.0	150	9.2
Carrazeda de Ansiães	63	5683	835.7	−7.2	14.45	383	29.4	0.0	0.0	0.0	100	5.8
Carregal do Sal	64	9290	767.6	−7.2	13.27	418	24.8	0.0	0.0	0.0	125	7.5
Cartaxo	65	23740	703.3	−7.1	12.16	458	20.8	0.0	0.0	0.0	158	9.7
Cascais	66	212474	657.1	−6.6	11.36	491	18.2	0.0	0.0	0.0	189	11.9
Castanheira de Pêra	67	2650	747.7	−7.1	12.93	430	23.5	0.0	0.0	0.0	134	8.1
Castelo Branco	68	52192	809.2	−7.2	13.99	396	27.5	0.0	0.0	0.0	109	6.4
Castelo de Paiva	69	15567	753.4	−7.1	13.03	426	23.9	0.0	0.0	0.0	132	7.9

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Castelo de Vide	70	2951	814.8	−7.2	14.09	393	27.9	0.0	0.0	0.0	107	6.2
Castro Daire	71	13928	778.1	−7.2	13.45	412	25.5	0.0	0.0	0.0	121	7.2
Castro Marim	72	6274	869.8	−7.2	15.04	368	31.8	0.0	0.0	0.0	90	5.1
Castro Verde	73	6946	798.6	−7.2	13.81	402	26.8	0.0	0.0	0.0	113	6.6
Celorico da Beira	74	6978	820.5	−7.2	14.19	391	28.3	0.0	0.0	0.0	105	6.1
Celorico de Basto	75	19075	781.7	−7.2	13.51	411	25.7	0.0	0.0	0.0	119	7.1
Chamusca	76	9253	727.3	−7.1	12.57	442	22.2	0.0	0.0	0.0	145	8.8
Chaves	77	39345	833.4	−7.2	14.41	384	29.2	0.0	0.0	0.0	101	5.8
Cinfães	78	18470	768.0	−7.2	13.28	418	24.8	0.0	0.0	0.0	125	7.5
Coimbra	79	133724	730.5	−7.1	12.63	440	22.4	0.0	0.0	0.0	143	8.7
Condeixa-a-Nova	80	17597	723.4	−7.1	12.51	445	22.0	0.0	0.0	0.0	147	8.9
Constância	81	4002	739.0	−7.1	12.78	435	23.0	0.0	0.0	0.0	139	8.4
Coruche	82	17629	728.7	−7.1	12.60	441	22.3	0.0	0.0	0.0	144	8.7
Corvo	83	65	1211.3	−7.5	20.94	263	61.6	0.0	0.0	0.0	37	1.9
Covilhã	84	47127	808.5	−7.2	13.98	397	27.5	0.0	0.0	0.0	109	6.4
Crato	85	3185	799.6	−7.2	13.82	401	26.9	0.0	0.0	0.0	112	6.6
Cuba	86	4599	800.3	−7.2	13.84	401	26.9	0.0	0.0	0.0	112	6.6
Elvas	87	20706	846.6	−7.2	14.64	378	30.1	0.0	0.0	0.0	97	5.6
Entroncamento	88	21214	727.6	−7.1	12.58	442	22.3	0.0	0.0	0.0	144	8.8
Espinho	89	29484	721.2	−7.1	12.47	446	21.9	0.0	0.0	0.0	148	9.0
Esposende	90	34057	722.0	−7.1	12.48	445	21.9	0.0	0.0	0.0	147	9.0
Estarreja	91	25965	722.8	−7.1	12.50	445	22.0	0.0	0.0	0.0	147	8.9
Estremoz	92	12816	811.0	−7.2	14.02	395	27.7	0.0	0.0	0.0	108	6.3

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Évora	93	52454	789.6	−7.2	13.65	406	26.2	0.0	0.0	0.0	116	6.9
Fafe	94	48271	769.6	−7.2	13.31	417	24.9	0.0	0.0	0.0	124	7.4
Faro	95	60974	837.9	−7.2	14.49	382	29.5	0.0	0.0	0.0	99	5.7
Felgueiras	96	56576	765.5	−7.1	13.23	419	24.6	0.0	0.0	0.0	126	7.5
Ferreira do Alentejo	97	7848	791.7	−7.2	13.69	405	26.4	0.0	0.0	0.0	116	6.8
Ferreira do Zêzere	98	7989	741.2	−7.1	12.81	434	23.1	0.0	0.0	0.0	138	8.3
Figueira da Foz	99	58866	692.7	−6.8	11.98	465	20.2	0.0	0.0	0.0	165	10.2
Figueira de Castelo Rodrigo	100	5652	859.0	−7.2	14.85	373	31.0	0.0	0.0	0.0	93	5.3
Figueiró dos Vinhos	101	5608	742.2	−7.1	12.83	433	23.2	0.0	0.0	0.0	137	8.3
Fornos de Algodres	102	4561	807.8	−7.2	13.97	397	27.4	0.0	0.0	0.0	110	6.4
Freixo de Espada à Cinta	103	3312	874.7	−7.2	15.12	366	32.2	0.0	0.0	0.0	89	5.0
Fronteira	104	2986	802.3	−7.2	13.87	400	27.1	0.0	0.0	0.0	112	6.5
Funchal	105	104129	776.6	−7.2	13.43	413	25.4	0.0	0.0	0.0	122	7.2
Fundão	106	26719	808.2	−7.2	13.97	397	27.5	0.0	0.0	0.0	109	6.4
Gavião	107	3347	773.2	−7.2	13.37	415	25.1	0.0	0.0	0.0	123	7.3
Góis	108	3825	756.6	−7.1	13.08	425	24.1	0.0	0.0	0.0	130	7.8
Golegã	109	5375	726.5	−7.1	12.56	443	22.2	0.0	0.0	0.0	145	8.8
Gondomar	110	165631	732.9	−7.1	12.67	439	22.6	0.0	0.0	0.0	142	8.6
Gouveia	111	12486	802.3	−7.2	13.87	400	27.1	0.0	0.0	0.0	112	6.5
Grândola	112	14570	742.9	−7.1	12.84	433	23.2	0.0	0.0	0.0	137	8.2
Guarda	113	39103	830.1	−7.2	14.35	386	29.0	0.0	0.0	0.0	102	5.9
Guimarães	114	152792	758.9	−7.1	13.12	423	24.2	0.0	0.0	0.0	129	7.7
Horta	115	14542	1014.0	−7.4	17.53	315	43.2	0.0	0.0	0.0	60	3.2

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Idanha-a-Nova	116	8157	830.4	−7.2	14.36	386	29.0	0.0	0.0	0.0	102	5.9
Ílhavo	117	38405	712.8	−7.1	12.32	451	21.4	0.0	0.0	0.0	153	9.3
Lagoa (Açores)	118	14681	776.2	−7.2	13.42	413	25.3	0.0	0.0	0.0	122	7.2
Lagoa (Faro)	119	22748	790.3	−7.2	13.66	406	26.3	0.0	0.0	0.0	116	6.8
Lagos	120	30442	773.8	−7.2	13.38	415	25.2	0.0	0.0	0.0	123	7.3
Lajes das Flores	121	1464	1219.6	−7.5	21.09	261	62.4	0.0	0.0	0.0	37	1.9
Lajes do Pico	122	4498	879.4	−7.2	15.20	364	32.5	0.0	0.0	0.0	87	5.0
Lamego	123	24959	791.6	−7.2	13.69	405	26.3	0.0	0.0	0.0	116	6.8
Leiria	124	124857	697.2	−6.8	12.05	462	20.4	0.0	0.0	0.0	162	10.0
Lisboa	125	507220	681.3	−6.7	11.78	473	19.5	0.0	0.0	0.0	172	10.7
Loulé	126	68873	825.7	−7.2	14.27	388	28.7	0.0	0.0	0.0	103	6.0
Loures	127	211359	676.1	−6.7	11.69	477	19.2	0.0	0.0	0.0	175	10.9
Lourinhã	128	25670	657.1	−6.6	11.36	491	18.2	0.0	0.0	0.0	189	11.9
Lousã	129	17128	744.8	−7.1	12.88	431	23.3	0.0	0.0	0.0	136	8.2
Lousada	130	46790	756.4	−7.1	13.08	425	24.1	0.0	0.0	0.0	130	7.8
Mação	131	6323	767.4	−7.2	13.27	418	24.8	0.0	0.0	0.0	125	7.5
Macedo de Cavaleiros	132	14550	869.9	−7.2	15.04	368	31.8	0.0	0.0	0.0	90	5.1
Machico	133	20094	765.8	−7.1	13.24	419	24.7	0.0	0.0	0.0	126	7.5
Madalena	134	5875	1005.5	−7.3	17.38	317	42.5	0.0	0.0	0.0	61	3.3
Mafra	135	84008	660.5	−6.6	11.42	488	18.4	0.0	0.0	0.0	187	11.7
Maia	136	137727	727.6	−7.1	12.58	442	22.3	0.0	0.0	0.0	144	8.8
Mangualde	137	18618	789.0	−7.2	13.64	407	26.2	0.0	0.0	0.0	117	6.9
Manteigas	138	3037	806.1	−7.2	13.94	398	27.3	0.0	0.0	0.0	110	6.4

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Marco de Canaveses	139	51661	765.3	−7.1	13.23	420	24.6	0.0	0.0	0.0	126	7.5
Marinha Grande	140	38404	686.3	−6.7	11.87	469	19.8	0.0	0.0	0.0	169	10.4
Marvão	141	3054	821.6	−7.2	14.20	390	28.4	0.0	0.0	0.0	105	6.1
Matosinhos	142	174382	720.8	−7.1	12.46	446	21.8	0.0	0.0	0.0	148	9.0
Mealhada	143	19892	729.0	−7.1	12.60	441	22.3	0.0	0.0	0.0	144	8.7
Mêda	144	4617	835.1	−7.2	14.44	384	29.3	0.0	0.0	0.0	100	5.8
Melgaço	145	8144	781.5	−7.2	13.51	411	25.7	0.0	0.0	0.0	120	7.1
Mértola	146	6202	836.0	−7.2	14.45	383	29.4	0.0	0.0	0.0	100	5.8
Mesão Frio	147	3996	787.5	−7.2	13.62	407	26.1	0.0	0.0	0.0	117	6.9
Mira	148	11831	705.1	−7.1	12.19	456	20.9	0.0	0.0	0.0	157	9.6
Miranda do Corvo	149	12687	737.5	−7.1	12.75	436	22.9	0.0	0.0	0.0	139	8.4
Miranda do Douro	150	6877	925.5	−7.3	16.00	345	36.0	0.0	0.0	0.0	76	4.3
Mirandela	151	21808	850.4	−7.2	14.70	377	30.4	0.0	0.0	0.0	96	5.5
Mogadouro	152	8481	886.6	−7.3	15.33	361	33.0	0.0	0.0	0.0	86	4.8
Moimenta da Beira	153	9729	805.7	−7.2	13.93	398	27.3	0.0	0.0	0.0	110	6.5
Moita	154	64526	694.9	−6.8	12.01	463	20.3	0.0	0.0	0.0	163	10.1
Monção	155	17902	762.9	−7.1	13.19	421	24.5	0.0	0.0	0.0	127	7.6
Monchique	156	5182	774.2	−7.2	13.39	415	25.2	0.0	0.0	0.0	123	7.3
Mondim de Basto	157	6985	786.0	−7.2	13.59	408	26.0	0.0	0.0	0.0	118	7.0
Monforte	158	2989	820.4	−7.2	14.18	391	28.3	0.0	0.0	0.0	105	6.1
Montalegre	159	9090	809.8	−7.2	14.00	396	27.6	0.0	0.0	0.0	109	6.4
Montemor-o-Novo	160	15740	761.1	−7.1	13.16	422	24.4	0.0	0.0	0.0	128	7.7
Montemor-o-Velho	161	25230	707.7	−7.1	12.24	455	21.1	0.0	0.0	0.0	155	9.5

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Montijo	162	56887	695.1	-6.8	12.02	463	20.3	0.0	0.0	0.0	163	10.1
Mora	163	4188	759.9	-7.1	13.14	423	24.3	0.0	0.0	0.0	129	7.7
Mortágua	164	8856	747.5	-7.1	12.92	430	23.5	0.0	0.0	0.0	134	8.1
Moura	165	13749	838.6	-7.2	14.50	382	29.6	0.0	0.0	0.0	99	5.7
Mourão	166	2456	841.4	-7.2	14.55	381	29.8	0.0	0.0	0.0	98	5.7
Murça	167	5480	826.8	-7.2	14.29	388	28.7	0.0	0.0	0.0	103	6.0
Murtosa	168	10244	717.1	-7.1	12.40	449	21.6	0.0	0.0	0.0	150	9.2
Nazaré	169	14180	675.2	-6.7	11.67	477	19.2	0.0	0.0	0.0	176	11.0
Nelas	170	13030	780.7	-7.2	13.50	411	25.6	0.0	0.0	0.0	120	7.1
Nisa	171	6149	797.3	-7.2	13.78	402	26.7	0.0	0.0	0.0	113	6.7
Nordeste	172	4875	737.6	-7.1	12.75	436	22.9	0.0	0.0	0.0	139	8.4
Óbidos	173	11719	669.5	-6.7	11.57	481	18.9	0.0	0.0	0.0	180	11.3
Odemira	174	24621	756.2	-7.1	13.07	425	24.0	0.0	0.0	0.0	130	7.8
Odivelas	175	159602	675.1	-6.7	11.67	477	19.2	0.0	0.0	0.0	176	11.0
Oeiras	176	176218	666.8	-6.6	11.53	483	18.7	0.0	0.0	0.0	182	11.4
Oleiros	177	5045	773.0	-7.2	13.36	415	25.1	0.0	0.0	0.0	123	7.3
Olhão	178	44607	844.9	-7.2	14.61	379	30.0	0.0	0.0	0.0	97	5.6
Oliveira de Azeméis	179	66113	732.1	-7.1	12.66	439	22.5	0.0	0.0	0.0	142	8.6
Oliveira de Frades	180	9920	755.7	-7.1	13.07	425	24.0	0.0	0.0	0.0	131	7.8
Oliveira do Bairro	181	23944	726.5	-7.1	12.56	443	22.2	0.0	0.0	0.0	145	8.8
Oliveira do Hospital	182	19331	778.7	-7.2	13.46	412	25.5	0.0	0.0	0.0	121	7.2
Ourém	183	44068	715.8	-7.1	12.38	449	21.5	0.0	0.0	0.0	151	9.2
Ourique	184	4653	788.5	-7.2	13.63	407	26.1	0.0	0.0	0.0	117	6.9

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Ovar	185	54120	719.9	−7.1	12.45	447	21.8	0.0	0.0	0.0	149	9.1
Paços de Ferreira	186	56709	748.5	−7.1	12.94	429	23.6	0.0	0.0	0.0	134	8.1
Palmela	187	64214	704.4	−7.1	12.18	457	20.9	0.0	0.0	0.0	157	9.7
Pampilhosa da Serra	188	4052	769.8	−7.2	13.31	417	24.9	0.0	0.0	0.0	124	7.4
Paredes	189	86072	750.6	−7.1	12.98	428	23.7	0.0	0.0	0.0	133	8.0
Paredes de Coura	190	8560	751.0	−7.1	12.98	428	23.7	0.0	0.0	0.0	133	8.0
Pedrógão Grande	191	3429	753.2	−7.1	13.02	426	23.9	0.0	0.0	0.0	132	7.9
Penacova	192	13812	742.4	−7.1	12.84	433	23.2	0.0	0.0	0.0	137	8.3
Penafiel	193	69922	754.7	−7.1	13.05	426	24.0	0.0	0.0	0.0	131	7.9
Penalva do Castelo	194	7175	795.0	−7.2	13.74	403	26.6	0.0	0.0	0.0	114	6.7
Penamacor	195	4831	836.5	−7.2	14.46	383	29.4	0.0	0.0	0.0	100	5.8
Penedono	196	2610	824.4	−7.2	14.25	389	28.6	0.0	0.0	0.0	104	6.0
Penela	197	5439	733.0	−7.1	12.67	439	22.6	0.0	0.0	0.0	142	8.6
Peniche	198	26487	650.3	−6.6	11.24	496	17.8	0.0	0.0	0.0	195	12.3
Peso da Régua	199	15830	794.7	−7.2	13.74	404	26.6	0.0	0.0	0.0	114	6.7
Pinhel	200	8607	849.0	−7.2	14.68	377	30.3	0.0	0.0	0.0	96	5.5
Pombal	201	51684	712.0	−7.1	12.31	452	21.3	0.0	0.0	0.0	153	9.4
Ponta Delgada	202	67864	784.5	−7.2	13.56	409	25.9	0.0	0.0	0.0	118	7.0
Ponta do Sol	203	8544	770.9	−7.2	13.33	416	25.0	0.0	0.0	0.0	124	7.4
Ponte da Barca	204	11210	759.2	−7.1	13.13	423	24.2	0.0	0.0	0.0	129	7.7
Ponte de Lima	205	41499	744.6	−7.1	12.87	432	23.3	0.0	0.0	0.0	136	8.2
Ponte de Sôr	206	15092	768.8	−7.2	13.29	418	24.9	0.0	0.0	0.0	125	7.4
Portalegre	207	22359	818.0	−7.2	14.14	392	28.1	0.0	0.0	0.0	106	6.2

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Portel	208	5870	812.6	−7.2	14.05	395	27.8	0.0	0.0	0.0	108	6.3
Portimão	209	55416	783.2	−7.2	13.54	410	25.8	0.0	0.0	0.0	119	7.0
Porto	210	215284	726.5	−7.1	12.56	443	22.2	0.0	0.0	0.0	145	8.8
Porto de Mós	211	23288	696.6	−6.8	12.04	462	20.4	0.0	0.0	0.0	162	10.0
Porto Moniz	212	2350	750.9	−7.1	12.98	428	23.7	0.0	0.0	0.0	133	8.0
Porto Santo	213	5176	731.2	−7.1	12.64	440	22.5	0.0	0.0	0.0	143	8.6
Póvoa de Lanhoso	214	21446	764.6	−7.1	13.22	420	24.6	0.0	0.0	0.0	127	7.6
Póvoa de Varzim	215	62510	719.4	−7.1	12.44	447	21.8	0.0	0.0	0.0	149	9.1
Povoação	216	5954	748.3	−7.1	12.94	429	23.5	0.0	0.0	0.0	134	8.1
Proença-a-Nova	217	7390	772.5	−7.2	13.36	416	25.1	0.0	0.0	0.0	123	7.3
Redondo	218	6387	818.0	−7.2	14.14	392	28.1	0.0	0.0	0.0	106	6.2
Reguengos de Monsaraz	219	10036	824.0	−7.2	14.25	389	28.5	0.0	0.0	0.0	104	6.0
Resende	220	10241	778.8	−7.2	13.46	412	25.5	0.0	0.0	0.0	121	7.1
Ribeira Brava	221	12411	772.1	−7.2	13.35	416	25.1	0.0	0.0	0.0	123	7.3
Ribeira de Pena	222	6031	800.9	−7.2	13.85	400	27.0	0.0	0.0	0.0	112	6.6
Ribeira Grande	223	32698	768.8	−7.2	13.29	418	24.9	0.0	0.0	0.0	125	7.4
Rio Maior	224	20340	688.3	−6.7	11.90	468	19.9	0.0	0.0	0.0	167	10.4
Sabrosa	225	5917	814.0	−7.2	14.07	394	27.9	0.0	0.0	0.0	107	6.3
Sabugal	226	10748	843.8	−7.2	14.59	380	29.9	0.0	0.0	0.0	98	5.6
Salvaterra de Magos	227	21268	704.7	−7.1	12.18	457	20.9	0.0	0.0	0.0	157	9.7
Santa Comba Dão	228	10506	756.0	−7.1	13.07	425	24.0	0.0	0.0	0.0	131	7.8
Santa Cruz	229	44744	770.5	−7.2	13.32	417	25.0	0.0	0.0	0.0	124	7.4
Santa Cruz da Graciosa	230	4225	952.4	−7.3	16.47	335	38.1	0.0	0.0	0.0	71	3.9

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Santa Cruz das Flores	231	2164	1214.9	−7.5	21.00	262	62.0	0.0	0.0	0.0	37	1.9
Santa Maria da Feira	232	138525	727.5	−7.1	12.58	442	22.3	0.0	0.0	0.0	145	8.8
Santa Marta de Penaguião	233	6649	794.5	−7.2	13.74	404	26.5	0.0	0.0	0.0	114	6.7
Santana	234	6750	757.9	−7.1	13.10	424	24.2	0.0	0.0	0.0	130	7.8
Santarém	235	57398	711.4	−7.1	12.30	452	21.3	0.0	0.0	0.0	153	9.4
Santiago do Cacém	236	28725	737.0	−7.1	12.74	436	22.8	0.0	0.0	0.0	140	8.4
Santo Tirso	237	68221	741.7	−7.1	12.82	433	23.1	0.0	0.0	0.0	137	8.3
São Brás de Alportel	238	10416	835.9	−7.2	14.45	383	29.4	0.0	0.0	0.0	100	5.8
São João da Madeira	239	21761	731.1	−7.1	12.64	440	22.5	0.0	0.0	0.0	143	8.6
São João da Pesqueira	240	7154	826.0	−7.2	14.28	388	28.7	0.0	0.0	0.0	103	6.0
São Pedro do Sul	241	15488	764.6	−7.1	13.22	420	24.6	0.0	0.0	0.0	127	7.6
São Roque do Pico	242	3264	781.1	−7.2	13.50	411	25.7	0.0	0.0	0.0	120	7.1
São Vicente	243	5150	757.7	−7.1	13.10	424	24.1	0.0	0.0	0.0	130	7.8
Sardoal	244	3739	753.3	−7.1	13.02	426	23.9	0.0	0.0	0.0	132	7.9
Sátão	245	11602	792.8	−7.2	13.71	405	26.4	0.0	0.0	0.0	115	6.8
Seia	246	22412	791.9	−7.2	13.69	405	26.4	0.0	0.0	0.0	115	6.8
Seixal	247	166835	685.7	−6.7	11.86	470	19.8	0.0	0.0	0.0	169	10.5
Sernancelhe	248	5384	814.8	−7.2	14.09	393	27.9	0.0	0.0	0.0	107	6.2
Serpa	249	14374	831.6	−7.2	14.38	385	29.1	0.0	0.0	0.0	101	5.9
Sertã	250	14682	757.4	−7.1	13.09	424	24.1	0.0	0.0	0.0	130	7.8
Sesimbra	251	51559	690.4	−6.8	11.94	466	20.0	0.0	0.0	0.0	166	10.3
Setúbal	252	115758	705.3	−7.1	12.19	456	20.9	0.0	0.0	0.0	157	9.6
Sever do Vouga	253	11403	739.6	−7.1	12.79	435	23.0	0.0	0.0	0.0	138	8.3

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Silves	254	36174	789.2	-7.2	13.64	407	26.2	0.0	0.0	0.0	116	6.9
Sines	255	13631	724.3	-7.1	12.52	444	22.1	0.0	0.0	0.0	146	8.9
Sintra	256	388434	658.7	-6.6	11.39	490	18.3	0.0	0.0	0.0	188	11.8
Sobral de Monte Agraço	257	10490	674.3	-6.7	11.66	478	19.1	0.0	0.0	0.0	177	11.0
Soure	258	17277	712.4	-7.1	12.32	452	21.3	0.0	0.0	0.0	153	9.3
Sousel	259	4454	801.6	-7.2	13.86	400	27.0	0.0	0.0	0.0	112	6.6
Tábua	260	11403	764.4	-7.1	13.22	420	24.6	0.0	0.0	0.0	127	7.6
Tabuaço	261	6017	812.0	-7.2	14.04	395	27.7	0.0	0.0	0.0	108	6.3
Tarouca	262	7761	792.6	-7.2	13.70	405	26.4	0.0	0.0	0.0	115	6.8
Tavira	263	24750	856.6	-7.2	14.81	374	30.8	0.0	0.0	0.0	94	5.4
Terras de Bouro	264	6405	765.2	-7.1	13.23	420	24.6	0.0	0.0	0.0	126	7.5
Tomar	265	36902	731.6	-7.1	12.65	439	22.5	0.0	0.0	0.0	142	8.6
Tondela	266	26548	761.3	-7.1	13.16	422	24.4	0.0	0.0	0.0	128	7.7
Torre de Moncorvo	267	7716	855.5	-7.2	14.79	374	30.8	0.0	0.0	0.0	94	5.4
Torres Novas	268	34970	721.3	-7.1	12.47	446	21.9	0.0	0.0	0.0	148	9.0
Torres Vedras	269	78220	664.0	-6.6	11.48	486	18.5	0.0	0.0	0.0	184	11.5
Trancoso	270	8946	825.4	-7.2	14.27	388	28.6	0.0	0.0	0.0	103	6.0
Trofa	271	38317	733.5	-7.1	12.68	438	22.6	0.0	0.0	0.0	141	8.6
Vagos	272	22685	711.1	-7.1	12.29	452	21.3	0.0	0.0	0.0	154	9.4
Vale de Cambra	273	21399	739.1	-7.1	12.78	435	23.0	0.0	0.0	0.0	139	8.4
Valença	274	13283	748.3	-7.1	12.94	429	23.6	0.0	0.0	0.0	134	8.1
Valongo	275	96570	735.7	-7.1	12.72	437	22.8	0.0	0.0	0.0	140	8.5
Valpaços	276	14932	842.9	-7.2	14.57	380	29.9	0.0	0.0	0.0	98	5.6

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Velas	277	5137	975.8	-7.3	16.87	327	40.0	0.0	0.0	0.0	66	3.6
Vendas Novas	278	11259	739.7	-7.1	12.79	434	23.0	0.0	0.0	0.0	138	8.3
Viana do Alentejo	279	5142	786.3	-7.2	13.59	408	26.0	0.0	0.0	0.0	118	6.9
Viana do Castelo	280	84636	722.5	-7.1	12.49	445	22.0	0.0	0.0	0.0	147	9.0
Vidigueira	281	5498	806.8	-7.2	13.95	397	27.4	0.0	0.0	0.0	110	6.4
Vieira do Minho	282	11898	776.2	-7.2	13.42	414	25.3	0.0	0.0	0.0	122	7.2
Vila da Praia da Vitória	283	21331	876.7	-7.2	15.16	365	32.3	0.0	0.0	0.0	88	5.0
Vila de Rei	284	3321	753.8	-7.1	13.03	426	23.9	0.0	0.0	0.0	132	7.9
Vila do Bispo	285	5154	755.4	-7.1	13.06	425	24.0	0.0	0.0	0.0	131	7.8
Vila do Conde	286	79579	720.4	-7.1	12.45	446	21.8	0.0	0.0	0.0	148	9.0
Vila do Porto	287	5623	773.1	-7.2	13.37	415	25.1	0.0	0.0	0.0	123	7.3
Vila Flor	288	6073	849.6	-7.2	14.69	377	30.3	0.0	0.0	0.0	96	5.5
Vila Franca de Xira	289	141603	689.1	-6.7	11.91	467	20.0	0.0	0.0	0.0	167	10.3
Vila Franca do Campo	290	11078	765.8	-7.1	13.24	419	24.7	0.0	0.0	0.0	126	7.5
Vila Nova da Barquinha	291	7402	730.6	-7.1	12.63	440	22.4	0.0	0.0	0.0	143	8.7
Vila Nova de Cerveira	292	8877	737.7	-7.1	12.75	436	22.9	0.0	0.0	0.0	139	8.4
Vila Nova de Famalicão	293	131738	739.6	-7.1	12.79	435	23.0	0.0	0.0	0.0	138	8.3
Vila Nova de Foz Côa	294	6541	841.9	-7.2	14.56	380	29.8	0.0	0.0	0.0	98	5.7
Vila Nova de Gaia	295	299938	725.6	-7.1	12.55	443	22.1	0.0	0.0	0.0	145	8.8
Vila Nova de Paiva	296	4723	794.7	-7.2	13.74	404	26.6	0.0	0.0	0.0	114	6.7
Vila Nova de Poiares	297	6929	744.1	-7.1	12.87	432	23.3	0.0	0.0	0.0	136	8.2
Vila Pouca de Aguiar	298	12009	813.4	-7.2	14.06	394	27.8	0.0	0.0	0.0	108	6.3
Vila Real	299	49868	800.9	-7.2	13.85	400	27.0	0.0	0.0	0.0	112	6.6

Table D.2.1: Medium Asteroid's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[Pa]$	h/R_f	f	ϕ^+ $[J/m^2]$	ϕ^- $[J/m^2]$	L_e $[nm]$	t_e $[am]$
Vila Real de Santo António	300	18888	872.9	-7.2	15.09	367	32.0	0.0	0.0	0.0	89	5.1
Vila Velha de Ródão	301	3167	792.0	-7.2	13.69	405	26.4	0.0	0.0	0.0	115	6.8
Vila Verde	302	46865	752.9	-7.1	13.02	427	23.8	0.0	0.0	0.0	132	7.9
Vila Viçosa	303	7719	826.6	-7.2	14.29	388	28.7	0.0	0.0	0.0	103	6.0
Vimioso	304	4070	906.3	-7.3	15.67	353	34.5	0.0	0.0	0.0	81	4.5
Vinhais	305	7847	873.2	-7.2	15.10	367	32.1	0.0	0.0	0.0	89	5.1
Viseu	306	96991	777.1	-7.2	13.44	413	25.4	0.0	0.0	0.0	121	7.2
Vizela	307	23840	760.3	-7.1	13.14	422	24.3	0.0	0.0	0.0	129	7.7
Vouzela	308	9661	760.8	-7.1	13.15	422	24.3	0.0	0.0	0.0	128	7.7

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Abrantes	127.0	18	317	1.842	1.113	1.520	1.400	0.970	1.325	0.552	1.926	2.629
Águeda	79.0	4	762	1.761	1.719	3.340	1.338	1.499	2.911	0.484	2.850	5.536
Aguiar da Beira	149.0	450	989	1.739	1.408	2.015	1.321	1.228	1.757	0.466	2.306	3.301
Alandroal	159.0	111	416	1.714	0.955	1.274	1.302	0.832	1.111	0.447	1.542	2.058
Albergaria-a-Velha	74.0	0	425	1.752	1.821	2.789	1.331	1.588	2.431	0.477	3.004	4.600
Albufeira	47.0	0	227	1.508	2.661	3.415	1.146	2.319	2.977	0.308	3.805	4.885
Alcácer do Sal	34.0	0	254	1.622	3.815	5.026	1.233	3.325	4.381	0.381	5.849	7.707
Alcanena	85.0	43	678	1.837	1.711	3.000	1.396	1.491	2.615	0.547	2.952	5.175
Alcobaça	49.0	0	504	1.811	2.797	4.558	1.376	2.438	3.974	0.525	4.761	7.760
Alcochete	30.0	0	61	1.727	4.460	4.800	1.312	3.888	4.185	0.457	7.256	7.810
Alcoutim	112.0	25	379	1.540	1.164	1.663	1.170	1.014	1.450	0.328	1.698	2.427
Alenquer	106.0	2	666	1.981	1.355	2.478	1.505	1.182	2.160	0.681	2.513	4.593
Alfândega da Fé	188.0	150	1199	1.694	0.837	1.762	1.287	0.730	1.536	0.432	1.337	2.814
Alijó	146.0	75	1000	1.698	0.994	2.045	1.290	0.867	1.783	0.435	1.591	3.274
Aljezur	36.0	0	370	1.600	3.578	5.233	1.216	3.119	4.562	0.366	5.415	7.920
Aljustrel	110.0	63	258	1.699	1.302	1.596	1.291	1.135	1.391	0.436	2.086	2.557
Almada	27.0	0	125	1.759	5.002	5.783	1.336	4.360	5.041	0.482	8.280	9.574
Almeida	204.0	500	845	1.746	1.072	1.356	1.326	0.934	1.182	0.472	1.762	2.229
Almeirim	119.0	5	171	1.920	1.193	1.439	1.459	1.040	1.254	0.621	2.147	2.589
Almodôvar	115.0	150	577	1.659	1.354	1.963	1.260	1.181	1.711	0.407	2.121	3.074
Alpiarça	126.0	9	132	1.934	1.137	1.310	1.470	0.991	1.142	0.636	2.060	2.374
Alter do Chão	162.0	147	413	1.802	0.999	1.279	1.369	0.871	1.115	0.517	1.692	2.167

Table D.2.2: Medium Asteroid’s tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Alvaiázere	110.0	96	618	1.843	1.407	2.227	1.400	1.227	1.942	0.552	2.436	3.855
Alvito	100.0	100	315	1.666	1.479	1.832	1.266	1.289	1.597	0.412	2.325	2.881
Amadora	40.0	50	258	1.819	3.648	4.541	1.382	3.180	3.959	0.532	6.238	7.764
Amarante	101.0	50	1348	1.711	1.401	3.541	1.300	1.221	3.086	0.445	2.259	5.709
Amares	79.0	24	901	1.688	1.725	3.561	1.283	1.504	3.104	0.428	2.747	5.672
Anadia	101.0	13	525	1.824	1.384	2.255	1.386	1.206	1.966	0.536	2.371	3.865
Angra do Heroísmo	9.6	0	1021	1.303	12.108	27.560	0.990	10.554	24.024	0.202	15.069	34.301
Ansião	110.0	175	533	1.857	1.538	2.102	1.411	1.340	1.832	0.565	2.681	3.665
Arcos de Valdevez	81.0	17	1416	1.689	1.669	4.526	1.284	1.455	3.946	0.429	2.659	7.212
Arganil	148.0	75	1418	1.872	1.030	2.610	1.423	0.898	2.275	0.578	1.809	4.586
Armamar	140.0	75	955	1.736	1.048	2.103	1.319	0.914	1.833	0.464	1.714	3.438
Arouca	96.0	50	1222	1.749	1.491	3.546	1.329	1.299	3.091	0.474	2.455	5.839
Arraiolos	158.0	150	412	1.849	1.041	1.328	1.405	0.907	1.157	0.558	1.807	2.306
Arronches	205.0	236	584	1.831	0.870	1.163	1.391	0.759	1.014	0.542	1.497	2.000
Arruda dos Vinhos	98.0	44	395	1.970	1.539	2.178	1.497	1.341	1.899	0.670	2.837	4.017
Aveiro	50.0	0	78	1.727	2.676	2.937	1.312	2.333	2.560	0.457	4.354	4.779
Avis	152.0	75	245	1.825	0.990	1.182	1.386	0.863	1.030	0.536	1.697	2.027
Azambuja	118.0	2	194	1.981	1.218	1.509	1.506	1.062	1.316	0.681	2.258	2.799
Baião	110.0	50	1416	1.729	1.293	3.372	1.314	1.128	2.940	0.459	2.107	5.494
Barcelos	52.0	9	488	1.680	2.567	4.087	1.277	2.238	3.563	0.422	4.070	6.480
Barrancos	203.0	125	412	1.700	0.756	0.991	1.292	0.659	0.864	0.437	1.212	1.588
Barreiro	30.0	0	76	1.746	4.486	4.912	1.327	3.910	4.282	0.472	7.378	8.079

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Batalha	50.0	50	523	1.779	2.886	4.492	1.351	2.516	3.916	0.498	4.829	7.517
Beja	127.0	25	284	1.689	1.075	1.412	1.283	0.937	1.231	0.429	1.712	2.250
Belmonte	203.0	446	890	1.856	1.064	1.444	1.410	0.928	1.258	0.563	1.854	2.515
Benavente	30.0	0	78	1.704	4.430	4.862	1.294	3.862	4.239	0.439	7.116	7.810
Bombarral	90.0	11	205	1.979	1.614	2.000	1.504	1.407	1.743	0.679	2.989	3.705
Borba	163.0	250	550	1.741	1.082	1.391	1.323	0.943	1.212	0.468	1.773	2.280
Boticas	134.0	250	1270	1.684	1.294	2.552	1.279	1.128	2.224	0.425	2.056	4.053
Braga	70.0	22	572	1.685	1.940	3.239	1.281	1.691	2.823	0.426	3.085	5.149
Bragança	220.0	325	1489	1.708	0.851	1.731	1.298	0.742	1.509	0.443	1.370	2.787
Cabeceiras de Basto	105.0	150	1200	1.688	1.496	3.150	1.282	1.304	2.746	0.428	2.382	5.015
Cadaval	94.0	46	665	1.976	1.610	2.789	1.502	1.404	2.431	0.676	2.979	5.158
Caldas da Rainha	36.0	0	255	1.810	3.806	5.019	1.375	3.317	4.375	0.524	6.475	8.539
Calheta (Açores)	3.5	0	942	1.200	31.872	69.401	0.912	27.783	60.497	0.159	36.684	79.880
Calheta (Madeira)	3.1	0	1640	1.502	40.264	122.805	1.142	35.098	107.050	0.305	57.386	175.028
Câmara de Lobos	3.8	0	1862	1.492	32.735	108.927	1.134	28.536	94.953	0.299	46.356	154.250
Caminha	42.0	0	805	1.674	3.137	6.295	1.272	2.735	5.487	0.418	4.958	9.946
Campo Maior	202.0	173	341	1.765	0.815	0.955	1.341	0.710	0.833	0.487	1.353	1.587
Cantanhede	75.0	0	137	1.790	1.817	2.128	1.361	1.584	1.855	0.508	3.059	3.583
Carrazeda de Ansiães	169.0	75	898	1.723	0.865	1.679	1.309	0.754	1.463	0.454	1.404	2.725
Carregal do Sal	115.0	150	375	1.760	1.395	1.725	1.337	1.216	1.504	0.483	2.311	2.859
Cartaxo	120.0	3	130	1.969	1.195	1.384	1.496	1.042	1.207	0.669	2.203	2.552
Cascais	24.0	0	475	1.814	5.715	9.109	1.379	4.982	7.940	0.528	9.747	15.534

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Castanheira de Pêra	131.0	350	1205	1.863	1.525	2.659	1.415	1.329	2.318	0.569	2.666	4.649
Castelo Branco	191.0	121	1227	1.858	0.837	1.841	1.412	0.729	1.605	0.565	1.459	3.212
Castelo de Paiva	95.0	25	694	1.745	1.460	2.644	1.326	1.273	2.305	0.471	2.399	4.344
Castelo de Vide	186.0	125	825	1.827	0.856	1.503	1.388	0.746	1.310	0.538	1.469	2.580
Castro Daire	121.0	200	1375	1.748	1.391	3.025	1.328	1.212	2.637	0.474	2.289	4.979
Castro Marim	82.0	0	276	1.458	1.500	2.017	1.108	1.307	1.758	0.280	2.077	2.794
Castro Verde	123.0	125	288	1.700	1.248	1.468	1.292	1.088	1.280	0.437	2.001	2.354
Celorico da Beira	165.0	375	1256	1.752	1.200	2.100	1.332	1.046	1.830	0.477	1.980	3.464
Celorico de Basto	102.0	75	851	1.690	1.420	2.678	1.284	1.237	2.335	0.429	2.263	4.270
Chamusca	102.0	11	200	1.837	1.372	1.691	1.396	1.196	1.474	0.547	2.367	2.918
Chaves	151.0	300	1050	1.683	1.203	2.023	1.279	1.049	1.764	0.424	1.910	3.213
Cinfães	110.0	12	1381	1.746	1.241	3.335	1.326	1.082	2.907	0.472	2.041	5.482
Coimbra	115.0	9	500	1.866	1.223	1.966	1.418	1.066	1.714	0.573	2.143	3.443
Condeixa-a-Nova	110.0	12	466	1.872	1.286	2.005	1.423	1.121	1.747	0.578	2.259	3.523
Constância	110.0	22	224	1.826	1.285	1.601	1.388	1.120	1.396	0.538	2.205	2.747
Coruche	145.0	7	264	1.968	0.994	1.310	1.495	0.866	1.142	0.668	1.831	2.414
Corvo	3.4	0	718	0.951	29.207	55.421	0.723	25.460	48.311	0.081	26.947	51.131
Covilhã	199.0	375	1993	1.885	1.032	2.453	1.432	0.899	2.138	0.589	1.824	4.336
Crato	161.0	150	445	1.799	1.007	1.320	1.367	0.878	1.151	0.514	1.704	2.233
Cuba	124.0	150	309	1.698	1.271	1.484	1.291	1.108	1.293	0.436	2.036	2.376
Elvas	187.0	150	496	1.741	0.853	1.164	1.323	0.744	1.015	0.468	1.400	1.909
Entroncamento	102.0	25	87	1.836	1.395	1.500	1.395	1.216	1.307	0.546	2.406	2.587

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Espinho	62.0	0	100	1.742	2.168	2.439	1.324	1.890	2.126	0.469	3.558	4.003
Esposende	36.0	0	281	1.674	3.660	4.946	1.272	3.191	4.311	0.418	5.783	7.815
Estarreja	64.0	0	130	1.743	2.101	2.442	1.325	1.831	2.129	0.470	3.450	4.010
Estremoz	200.0	205	653	1.880	0.877	1.268	1.428	0.764	1.105	0.585	1.547	2.236
Évora	153.0	150	441	1.804	1.062	1.387	1.371	0.925	1.209	0.519	1.801	2.352
Fafe	89.0	175	894	1.688	1.812	3.147	1.282	1.579	2.744	0.428	2.884	5.011
Faro	49.0	0	410	1.456	2.508	3.793	1.106	2.186	3.306	0.279	3.469	5.247
Felgueiras	82.0	145	575	1.681	1.902	2.767	1.277	1.658	2.412	0.423	3.015	4.387
Ferreira do Alentejo	105.0	24	277	1.673	1.292	1.689	1.271	1.126	1.472	0.417	2.039	2.666
Ferreira do Zêzere	115.0	125	451	1.834	1.387	1.875	1.394	1.209	1.635	0.545	2.389	3.231
Figueira da Foz	72.0	0	257	1.851	1.924	2.542	1.406	1.677	2.216	0.559	3.343	4.417
Figueira de Castelo Rodrigo	200.0	124	976	1.743	0.776	1.492	1.324	0.677	1.301	0.470	1.274	2.450
Figueiró dos Vinhos	120.0	125	1009	1.846	1.333	2.607	1.403	1.162	2.273	0.555	2.311	4.520
Fornos de Algodres	154.0	325	915	1.757	1.233	1.879	1.335	1.074	1.638	0.481	2.039	3.108
Freixo de Espada à Cinta	214.0	124	885	1.738	0.725	1.321	1.321	0.632	1.152	0.466	1.187	2.164
Fronteira	175.0	150	371	1.831	0.935	1.153	1.391	0.815	1.005	0.542	1.609	1.983
Funchal	3.1	0	1818	1.485	40.029	130.994	1.128	34.894	114.189	0.295	56.420	184.633
Fundão	198.0	275	1227	1.882	0.948	1.788	1.430	0.827	1.558	0.587	1.674	3.157
Gavião	143.0	50	312	1.823	1.021	1.336	1.385	0.890	1.165	0.535	1.749	2.289
Góis	144.0	150	1204	1.875	1.150	2.426	1.425	1.002	2.115	0.581	2.023	4.268
Golegã	100.0	14	95	1.833	1.403	1.543	1.393	1.223	1.345	0.544	2.417	2.657
Gondomar	70.0	5	470	1.733	1.927	3.040	1.317	1.680	2.650	0.462	3.145	4.962

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Gouveia	168.0	250	1626	1.811	1.071	2.474	1.376	0.933	2.156	0.525	1.822	4.211
Grândola	38.0	0	325	1.629	3.421	4.810	1.238	2.982	4.193	0.386	5.267	7.406
Guarda	184.0	441	1287	1.778	1.145	1.925	1.351	0.998	1.678	0.497	1.915	3.220
Guimarães	79.0	83	613	1.689	1.849	2.959	1.284	1.612	2.580	0.429	2.947	4.715
Horta	15.0	0	1043	1.150	7.279	16.770	0.874	6.346	14.619	0.140	8.045	18.533
Idanha-a-Nova	215.0	125	828	1.867	0.748	1.317	1.418	0.652	1.148	0.573	1.311	2.307
Ílhavo	48.0	0	61	1.728	2.789	3.001	1.313	2.431	2.616	0.458	4.540	4.886
Lagoa (Açores)	12.0	0	947	1.503	10.404	22.719	1.142	9.069	19.804	0.306	14.834	32.393
Lagoa (Faro)	36.0	0	103	1.523	3.491	3.940	1.157	3.043	3.435	0.317	5.039	5.688
Lagos	50.0	0	255	1.587	2.566	3.383	1.206	2.237	2.949	0.358	3.852	5.080
Lajes das Flores	4.6	0	830	0.945	21.524	43.856	0.718	18.763	38.230	0.080	19.747	40.235
Lajes do Pico	4.5	0	2351	1.313	25.929	102.127	0.998	22.602	89.025	0.206	32.507	128.037
Lamego	133.0	50	1122	1.744	1.074	2.429	1.325	0.937	2.118	0.470	1.765	3.990
Leiria	50.0	0	410	1.775	2.713	4.104	1.349	2.365	3.577	0.495	4.531	6.853
Lisboa	30.0	0	228	1.763	4.508	5.792	1.340	3.929	5.049	0.486	7.482	9.615
Loulé	44.0	0	589	1.469	2.806	4.871	1.117	2.446	4.246	0.286	3.915	6.798
Loures	30.0	0	409	1.778	4.526	6.840	1.351	3.945	5.962	0.497	7.570	11.440
Lourinhã	72.0	0	201	1.963	1.982	2.480	1.492	1.727	2.161	0.663	3.642	4.557
Lousã	130.0	75	1205	1.868	1.171	2.683	1.420	1.021	2.339	0.575	2.054	4.706
Lousada	85.0	175	578	1.711	1.910	2.699	1.300	1.665	2.353	0.445	3.080	4.353
Mação	108.0	47	643	1.742	1.318	2.245	1.324	1.148	1.957	0.469	2.161	3.682
Macedo de Cavaleiros	192.0	225	1263	1.694	0.885	1.780	1.287	0.771	1.552	0.433	1.413	2.845

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Machico	5.3	0	1480	1.510	23.613	67.297	1.148	20.584	58.663	0.310	33.824	96.398
Madalena	9.6	0	2351	1.153	11.392	44.870	0.876	9.930	39.113	0.142	12.627	49.734
Mafra	65.0	0	431	1.929	2.176	3.348	1.466	1.897	2.919	0.630	3.933	6.052
Maia	59.0	35	255	1.718	2.361	2.983	1.305	2.058	2.601	0.450	3.823	4.830
Mangualde	132.0	225	766	1.748	1.307	1.997	1.328	1.139	1.741	0.474	2.152	3.287
Manteigas	171.0	518	1993	1.809	1.319	2.796	1.374	1.150	2.437	0.523	2.243	4.754
Marco de Canaveses	100.0	8	962	1.727	1.351	2.947	1.312	1.178	2.569	0.457	2.199	4.794
Marinha Grande	47.0	0	165	1.797	2.904	3.503	1.365	2.532	3.054	0.513	4.907	5.919
Marvão	164.0	200	1027	1.747	1.026	1.874	1.327	0.894	1.634	0.473	1.687	3.083
Matosinhos	52.0	0	134	1.717	2.566	2.996	1.305	2.237	2.612	0.450	4.154	4.850
Mealhada	108.0	25	568	1.850	1.322	2.193	1.406	1.153	1.912	0.558	2.297	3.809
Mêda	179.0	225	945	1.751	0.964	1.642	1.330	0.841	1.431	0.476	1.590	2.707
Melgaço	99.0	25	1336	1.683	1.376	3.563	1.279	1.200	3.106	0.424	2.185	5.657
Mértola	157.0	25	371	1.692	0.870	1.235	1.285	0.758	1.076	0.431	1.388	1.970
Mesão Frio	123.0	50	1038	1.728	1.156	2.501	1.313	1.008	2.180	0.458	1.883	4.072
Mira	74.0	0	64	1.820	1.856	2.005	1.383	1.618	1.748	0.532	3.175	3.429
Miranda do Corvo	118.0	50	940	1.854	1.249	2.556	1.409	1.088	2.228	0.562	2.174	4.450
Miranda do Douro	248.0	400	911	1.695	0.802	1.143	1.288	0.699	0.997	0.433	1.282	1.828
Mirandela	173.0	175	941	1.696	0.934	1.668	1.288	0.814	1.454	0.434	1.494	2.667
Mogadouro	211.0	150	997	1.700	0.747	1.414	1.292	0.651	1.232	0.437	1.198	2.266
Moimenta da Beira	149.0	375	1011	1.749	1.328	2.046	1.329	1.157	1.784	0.474	2.186	3.370
Moita	30.0	0	58	1.727	4.461	4.785	1.313	3.889	4.171	0.458	7.261	7.788

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Monção	75.0	9	1114	1.670	1.774	4.198	1.269	1.547	3.659	0.415	2.796	6.615
Monchique	75.0	25	902	1.643	1.795	3.702	1.248	1.564	3.227	0.396	2.785	5.745
Mondim de Basto	103.0	100	1307	1.682	1.442	3.377	1.278	1.257	2.944	0.423	2.288	5.357
Monforte	191.0	225	402	1.825	0.923	1.082	1.387	0.804	0.943	0.537	1.583	1.856
Montalegre	133.0	175	1527	1.697	1.216	2.901	1.290	1.060	2.529	0.435	1.946	4.644
Montemor-o-Novo	132.0	25	424	1.826	1.075	1.595	1.387	0.937	1.390	0.537	1.844	2.736
Montemor-o-Velho	95.0	2	127	1.875	1.471	1.701	1.425	1.283	1.482	0.580	2.588	2.992
Montijo	30.0	0	135	1.727	4.461	5.213	1.312	3.888	4.545	0.457	7.258	8.483
Mora	176.0	38	206	1.967	0.850	1.021	1.495	0.741	0.890	0.667	1.566	1.880
Mortágua	127.0	75	768	1.851	1.193	2.138	1.407	1.040	1.864	0.559	2.074	3.717
Moura	163.0	75	584	1.700	0.891	1.409	1.292	0.777	1.228	0.437	1.428	2.259
Mourão	148.0	100	286	1.657	0.996	1.202	1.259	0.868	1.048	0.405	1.558	1.880
Murça	146.0	175	1031	1.687	1.104	2.074	1.282	0.963	1.808	0.427	1.757	3.300
Murtosa	47.0	0	17	1.714	2.837	2.897	1.303	2.473	2.525	0.447	4.583	4.681
Nazaré	22.0	0	177	1.758	6.138	7.496	1.336	5.350	6.534	0.482	10.160	12.408
Nelas	129.0	150	484	1.762	1.244	1.682	1.339	1.085	1.466	0.485	2.065	2.790
Nisa	153.0	50	463	1.783	0.944	1.403	1.355	0.823	1.223	0.502	1.584	2.353
Nordeste	11.0	0	1103	1.581	11.639	27.687	1.201	10.146	24.135	0.354	17.411	41.418
Óbidos	27.0	0	222	1.788	5.043	6.442	1.359	4.396	5.616	0.506	8.481	10.834
Odemira	48.0	0	515	1.622	2.702	4.441	1.232	2.355	3.871	0.381	4.142	6.808
Odivelas	64.0	24	339	1.880	2.247	3.106	1.428	1.959	2.707	0.585	3.962	5.477
Oeiras	25.0	0	199	1.790	5.449	6.805	1.360	4.750	5.932	0.507	9.174	11.456

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$	Collapse wave A_{800} $[mm]$	Collapse wave U_{min} $[cm]$	Collapse wave U_{max} $[cm]$
Oleiros	130.0	250	1085	1.786	1.374	2.467	1.357	1.198	2.150	0.504	2.309	4.145
Olhão	68.0	0	410	1.478	1.821	2.754	1.123	1.587	2.401	0.291	2.556	3.866
Oliveira de Azeméis	72.0	25	645	1.740	1.924	3.370	1.322	1.677	2.938	0.467	3.153	5.523
Oliveira de Frades	95.0	50	1062	1.738	1.502	3.289	1.321	1.309	2.867	0.466	2.459	5.386
Oliveira do Bairro	86.0	5	78	1.793	1.596	1.740	1.363	1.391	1.517	0.510	2.691	2.935
Oliveira do Hospital	159.0	150	1244	1.853	1.035	2.228	1.408	0.903	1.942	0.561	1.802	3.877
Ourém	91.0	95	678	1.838	1.697	2.803	1.397	1.480	2.444	0.548	2.931	4.840
Ourique	108.0	65	377	1.688	1.325	1.802	1.283	1.155	1.571	0.428	2.109	2.870
Ovar	57.0	0	225	1.733	2.352	3.013	1.317	2.050	2.626	0.462	3.838	4.918
Paços de Ferreira	77.0	175	570	1.711	2.108	2.962	1.300	1.838	2.582	0.445	3.399	4.776
Palmela	29.0	0	391	1.701	4.579	6.818	1.292	3.992	5.943	0.437	7.344	10.933
Pampilhosa da Serra	154.0	300	1418	1.865	1.242	2.504	1.417	1.082	2.183	0.572	2.174	4.384
Paredes	83.0	25	519	1.720	1.660	2.653	1.307	1.447	2.313	0.452	2.691	4.302
Paredes de Coura	70.0	125	883	1.687	2.185	3.975	1.282	1.904	3.465	0.427	3.476	6.324
Pedrógão Grande	133.0	150	779	1.852	1.237	2.057	1.407	1.079	1.793	0.560	2.152	3.577
Penacova	126.0	36	550	1.863	1.153	1.862	1.416	1.005	1.623	0.570	2.017	3.256
Penafiel	84.0	22	586	1.713	1.630	2.749	1.301	1.421	2.396	0.446	2.631	4.437
Penalva do Castelo	132.0	325	724	1.732	1.428	1.934	1.316	1.245	1.686	0.461	2.331	3.157
Penamacor	224.0	300	1076	1.875	0.856	1.460	1.425	0.746	1.273	0.581	1.507	2.569
Penedono	170.0	450	1000	1.755	1.240	1.786	1.334	1.081	1.557	0.479	2.049	2.951
Penela	115.0	150	873	1.859	1.434	2.525	1.412	1.250	2.201	0.566	2.501	4.405
Peniche	16.0	0	165	1.811	8.565	10.331	1.376	7.466	9.006	0.525	14.579	17.585

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Peso da Régua	130.0	50	1397	1.728	1.094	2.828	1.313	0.954	2.465	0.458	1.781	4.604
Pinhel	190.0	150	926	1.743	0.840	1.527	1.324	0.732	1.331	0.470	1.379	2.506
Pombal	65.0	0	560	1.775	2.087	3.549	1.349	1.820	3.093	0.495	3.487	5.927
Ponta Delgada	14.0	0	873	1.491	8.881	18.572	1.133	7.742	16.189	0.298	12.564	26.274
Ponta do Sol	4.3	0	1620	1.498	28.988	87.689	1.139	25.269	76.439	0.303	41.209	124.656
Ponte da Barca	80.0	25	1359	1.691	1.707	4.467	1.285	1.488	3.894	0.430	2.723	7.126
Ponte de Lima	66.0	3	835	1.693	2.015	4.102	1.286	1.756	3.576	0.431	3.216	6.549
Ponte de Sôr	138.0	46	285	1.821	1.053	1.350	1.384	0.918	1.177	0.533	1.802	2.311
Portalegre	188.0	250	1027	1.823	0.960	1.670	1.385	0.837	1.456	0.535	1.645	2.862
Portel	132.0	100	424	1.688	1.127	1.533	1.282	0.983	1.337	0.428	1.795	2.441
Portimão	46.0	0	325	1.558	2.763	3.886	1.184	2.409	3.387	0.339	4.077	5.734
Porto	56.0	0	157	1.713	2.380	2.847	1.302	2.075	2.482	0.447	3.843	4.597
Porto de Mós	44.0	50	615	1.760	3.262	5.431	1.337	2.844	4.734	0.483	5.405	8.997
Porto Moniz	4.0	0	1640	1.538	31.571	96.290	1.169	27.520	83.937	0.327	46.006	140.317
Porto Santo	6.3	0	517	1.584	20.346	33.495	1.204	17.736	29.198	0.356	30.502	50.215
Póvoa de Lanhoso	83.0	50	743	1.685	1.692	3.072	1.281	1.475	2.678	0.426	2.690	4.884
Póvoa de Varzim	33.0	0	202	1.673	3.992	5.000	1.272	3.480	4.358	0.417	6.303	7.895
Povoação	5.4	0	1103	1.546	23.448	55.778	1.175	20.440	48.622	0.332	34.344	81.696
Proença-a-Nova	128.0	114	954	1.782	1.213	2.329	1.354	1.058	2.030	0.501	2.035	3.904
Redondo	152.0	187	653	1.725	1.085	1.598	1.310	0.946	1.393	0.455	1.764	2.597
Reguengos de Monsaraz	133.0	100	363	1.662	1.111	1.435	1.263	0.968	1.251	0.409	1.743	2.252
Resende	116.0	50	1218	1.733	1.228	2.915	1.317	1.070	2.541	0.462	2.005	4.759

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Ribeira Brava	3.8	0	1725	1.495	32.767	103.420	1.136	28.563	90.153	0.301	46.485	146.718
Ribeira de Pena	121.0	153	1286	1.689	1.303	2.852	1.284	1.136	2.486	0.429	2.076	4.545
Ribeira Grande	8.2	0	877	1.510	15.261	31.990	1.147	13.303	27.886	0.310	21.857	45.818
Rio Maior	97.0	25	497	1.942	1.509	2.372	1.476	1.315	2.068	0.643	2.746	4.317
Sabrosa	143.0	75	1100	1.712	1.019	2.213	1.301	0.888	1.929	0.446	1.644	3.570
Sabugal	225.0	450	1223	1.856	0.964	1.559	1.411	0.840	1.359	0.564	1.679	2.718
Salvaterra de Magos	89.0	2	105	1.866	1.567	1.768	1.418	1.366	1.541	0.572	2.743	3.096
Santa Comba Dão	132.0	137	352	1.841	1.226	1.507	1.399	1.069	1.314	0.550	2.119	2.606
Santa Cruz	3.7	0	1415	1.498	33.684	93.262	1.138	29.363	81.297	0.303	47.871	132.542
Santa Cruz da Graciosa	8.7	0	402	1.217	12.913	19.402	0.925	11.257	16.913	0.166	15.065	22.635
Santa Cruz das Flores	3.4	0	914	0.948	29.163	62.482	0.720	25.422	54.466	0.080	26.829	57.481
Santa Maria da Feira	73.0	25	450	1.755	1.906	2.888	1.334	1.661	2.517	0.479	3.149	4.771
Santa Marta de Penaguião	130.0	75	1416	1.729	1.126	2.853	1.313	0.982	2.487	0.458	1.835	4.646
Santana	7.2	0	1862	1.530	17.495	58.214	1.163	15.250	50.745	0.322	25.371	84.422
Santarém	130.0	3	529	1.976	1.105	1.829	1.501	0.963	1.594	0.676	2.044	3.383
Santiago do Cacém	38.0	0	370	1.643	3.435	5.024	1.249	2.995	4.379	0.396	5.332	7.798
Santo Tirso	61.0	36	535	1.687	2.266	3.619	1.282	1.975	3.154	0.427	3.607	5.760
São Brás de Alportel	45.0	125	530	1.452	3.153	4.534	1.104	2.749	3.952	0.277	4.352	6.257
São João da Madeira	74.0	150	276	1.748	2.161	2.447	1.328	1.883	2.133	0.474	3.557	4.028
São João da Pesqueira	164.0	75	994	1.735	0.895	1.834	1.318	0.780	1.599	0.464	1.462	2.998
São Pedro do Sul	104.0	75	1119	1.739	1.412	3.097	1.321	1.231	2.700	0.466	2.313	5.073
São Roque do Pico	4.8	0	2351	1.480	25.806	101.645	1.124	22.496	88.605	0.292	36.252	142.786

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$	Collapse wave A_{800} $[mm]$	Collapse wave U_{min} $[cm]$	Collapse wave U_{max} $[cm]$
São Vicente	4.7	0	1725	1.525	26.760	84.461	1.159	23.327	73.625	0.319	38.696	122.133
Sardoal	111.0	75	452	1.788	1.342	1.920	1.359	1.170	1.674	0.506	2.257	3.230
Sátão	132.0	375	859	1.738	1.494	2.109	1.321	1.302	1.839	0.466	2.446	3.453
Seia	163.0	175	1993	1.826	1.029	2.948	1.388	0.897	2.570	0.538	1.766	5.059
Seixal	30.0	0	81	1.752	4.493	4.947	1.331	3.916	4.313	0.477	7.410	8.160
Sernancelhe	152.0	475	964	1.733	1.406	1.945	1.317	1.225	1.695	0.462	2.294	3.175
Serpa	159.0	25	523	1.708	0.863	1.384	1.298	0.752	1.207	0.443	1.390	2.228
Sertã	132.0	125	1084	1.837	1.209	2.462	1.396	1.054	2.146	0.547	2.086	4.248
Sesimbra	9.9	0	380	1.688	13.364	19.711	1.283	11.649	17.182	0.428	21.276	31.382
Setúbal	29.0	0	501	1.698	4.576	7.442	1.291	3.989	6.487	0.436	7.329	11.919
Sever do Vouga	81.0	25	841	1.744	1.712	3.406	1.325	1.492	2.969	0.470	2.812	5.593
Silves	38.0	0	426	1.529	3.314	5.078	1.162	2.889	4.427	0.321	4.803	7.360
Sines	41.0	0	250	1.681	3.220	4.227	1.277	2.807	3.684	0.423	5.107	6.703
Sintra	37.0	0	528	1.847	3.741	6.210	1.404	3.261	5.413	0.556	6.490	10.774
Sobral de Monte Agraço	93.0	125	442	1.976	1.780	2.390	1.502	1.551	2.083	0.676	3.292	4.420
Soure	96.0	6	532	1.863	1.459	2.411	1.416	1.272	2.102	0.570	2.552	4.217
Sousel	175.0	150	454	1.833	0.936	1.235	1.393	0.816	1.077	0.544	1.611	2.127
Tábua	145.0	143	518	1.854	1.127	1.576	1.409	0.983	1.373	0.562	1.963	2.743
Tabuaço	152.0	75	985	1.740	0.967	1.972	1.323	0.843	1.719	0.468	1.585	3.233
Tarouca	137.0	325	1102	1.752	1.384	2.339	1.331	1.206	2.039	0.477	2.282	3.859
Tavira	52.0	0	541	1.428	2.340	3.922	1.085	2.040	3.419	0.263	3.177	5.325
Terras de Bouro	87.0	75	1525	1.694	1.666	4.427	1.287	1.452	3.859	0.432	2.661	7.072

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Tomar	89.0	32	350	1.787	1.591	2.199	1.358	1.387	1.917	0.505	2.675	3.697
Tondela	121.0	133	1075	1.794	1.315	2.642	1.363	1.146	2.303	0.511	2.218	4.457
Torre de Moncorvo	190.0	100	920	1.726	0.792	1.514	1.311	0.691	1.320	0.456	1.288	2.462
Torres Novas	88.0	13	678	1.814	1.584	2.879	1.378	1.381	2.510	0.527	2.700	4.909
Torres Vedras	71.0	0	394	1.937	1.996	2.979	1.472	1.740	2.597	0.638	3.623	5.407
Trancoso	166.0	425	986	1.742	1.240	1.808	1.324	1.081	1.576	0.469	2.034	2.965
Trofa	54.0	25	250	1.690	2.528	3.218	1.284	2.204	2.805	0.430	4.031	5.130
Vagos	51.0	0	68	1.740	2.634	2.858	1.322	2.296	2.491	0.467	4.317	4.684
Vale de Cambra	81.0	75	1046	1.745	1.817	3.833	1.326	1.584	3.341	0.472	2.986	6.300
Valença	65.0	0	784	1.681	2.031	4.022	1.277	1.771	3.506	0.423	3.221	6.378
Valongo	69.0	50	385	1.723	2.058	2.869	1.309	1.794	2.501	0.454	3.341	4.658
Valpaços	164.0	225	1148	1.692	1.035	1.967	1.286	0.902	1.714	0.431	1.651	3.138
Velas	3.0	0	1053	1.181	36.884	85.432	0.897	32.152	74.472	0.152	41.804	96.829
Vendas Novas	106.0	25	190	1.812	1.334	1.601	1.377	1.163	1.395	0.526	2.272	2.727
Viana do Alentejo	99.0	72	374	1.671	1.449	1.951	1.270	1.264	1.701	0.416	2.286	3.078
Viana do Castelo	35.0	0	823	1.671	3.761	7.630	1.270	3.278	6.651	0.415	5.930	12.030
Vidigueira	122.0	75	412	1.677	1.182	1.638	1.274	1.031	1.428	0.420	1.871	2.592
Vieira do Minho	95.0	75	1262	1.686	1.522	3.588	1.281	1.327	3.127	0.427	2.422	5.707
Vila da Praia da Vitória	22.0	0	808	1.344	5.366	10.786	1.021	4.678	9.402	0.221	6.879	13.827
Vila de Rei	128.0	125	594	1.835	1.246	1.878	1.395	1.086	1.637	0.546	2.149	3.238
Vila do Bispo	15.0	0	156	1.551	8.456	10.105	1.179	7.371	8.808	0.335	12.425	14.847
Vila do Conde	41.0	0	235	1.691	3.230	4.178	1.285	2.815	3.642	0.430	5.150	6.663

Table D.2.2: Medium Asteroid's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave			Collapse wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[mm]$	U_{min} $[cm]$	U_{max} $[cm]$
Vila do Porto	5.0	0	587	1.495	24.906	43.181	1.136	21.711	37.641	0.301	35.342	61.273
Vila Flor	177.0	123	837	1.708	0.867	1.538	1.298	0.756	1.341	0.443	1.397	2.477
Vila Franca de Xira	30.0	0	378	1.743	4.481	6.598	1.324	3.906	5.752	0.469	7.355	10.830
Vila Franca do Campo	7.7	0	947	1.515	16.279	35.549	1.151	14.191	30.989	0.313	23.390	51.078
Vila Nova da Barquinha	103.0	19	201	1.830	1.369	1.674	1.391	1.194	1.459	0.541	2.354	2.878
Vila Nova de Cerveira	54.0	0	638	1.680	2.444	4.394	1.277	2.131	3.830	0.422	3.875	6.964
Vila Nova de Famalicão	60.0	25	462	1.690	2.275	3.481	1.284	1.983	3.034	0.429	3.627	5.549
Vila Nova de Foz Côa	189.0	82	814	1.759	0.788	1.442	1.337	0.687	1.257	0.482	1.305	2.388
Vila Nova de Gaia	60.0	0	262	1.726	2.229	2.960	1.311	1.943	2.580	0.456	3.625	4.812
Vila Nova de Paiva	133.0	550	1036	1.736	1.702	2.315	1.319	1.484	2.018	0.464	2.784	3.786
Vila Nova de Poiares	125.0	42	458	1.855	1.168	1.745	1.410	1.018	1.521	0.563	2.034	3.039
Vila Pouca de Aguiar	133.0	225	1205	1.688	1.275	2.493	1.283	1.111	2.173	0.428	2.030	3.971
Vila Real	127.0	125	1350	1.705	1.210	2.813	1.295	1.055	2.452	0.440	1.945	4.521
Vila Real de Santo António	81.0	0	225	1.450	1.514	1.940	1.102	1.320	1.691	0.276	2.087	2.674
Vila Velha de Ródão	139.0	50	570	1.759	1.032	1.664	1.337	0.900	1.450	0.482	1.710	2.755
Vila Verde	72.0	21	789	1.687	1.885	3.649	1.282	1.643	3.181	0.427	3.000	5.807
Vila Viçosa	163.0	165	475	1.731	0.991	1.310	1.315	0.864	1.142	0.460	1.617	2.136
Vimioso	228.0	250	955	1.693	0.763	1.275	1.287	0.665	1.111	0.432	1.218	2.036
Vinhais	198.0	275	1273	1.701	0.901	1.738	1.293	0.786	1.515	0.438	1.446	2.788
Viseu	121.0	200	899	1.751	1.392	2.365	1.330	1.213	2.061	0.476	2.294	3.898
Vizela	74.0	125	478	1.674	2.058	2.844	1.272	1.794	2.479	0.417	3.251	4.492
Vouzela	103.0	125	1043	1.746	1.511	3.010	1.327	1.317	2.624	0.472	2.484	4.949

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities

	best				expected				worst			
Municipality	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_{seis}	V_p $[10^{-5}]$	C_p
Abrantes	6.1	0	3.4	1	5.2	0	2.3	0	5.0	0	4.4	1
Águeda	6.4	0	3.4	1	5.4	0	2.3	1	5.4	0	4.4	2
Aguiar da Beira	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	0
Alandroal	5.1	0	3.4	0	4.3	0	2.3	0	3.8	0	4.4	0
Albergaria-a-Velha	6.4	0	3.4	0	5.4	0	2.3	0	5.4	0	4.4	1
Albufeira	5.3	0	3.4	1	4.5	0	2.3	0	4.1	0	4.4	1
Alcácer do Sal	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Alcanena	6.7	0	3.4	0	5.7	0	2.3	0	5.8	0	4.4	0
Alcobaça	17.1	0	3.4	1	14.6	0	2.3	1	24.1	0	4.4	2
Alcochete	14.8	0	3.4	0	12.6	0	2.3	0	19.4	0	4.4	0
Alcoutim	4.8	0	3.4	0	4.1	0	2.3	0	3.5	0	4.4	0
Alenquer	16.6	0	3.4	1	14.2	0	2.3	1	23.0	0	4.4	1
Alfândega da Fé	4.7	0	3.4	0	4.0	0	2.3	0	3.4	0	4.4	0
Alijó	5.1	0	3.4	0	4.4	0	2.3	0	3.9	0	4.4	0
Aljezur	6.0	0	3.4	0	5.1	0	2.3	0	5.0	0	4.4	0
Aljustrel	5.6	0	3.4	0	4.8	0	2.3	0	4.4	0	4.4	0
Almada	17.7	0	3.4	5	15.2	0	2.3	3	25.5	0	4.4	7
Almeida	4.7	0	3.4	0	4.0	0	2.3	0	3.4	0	4.4	0
Almeirim	6.6	0	3.4	0	5.6	0	2.3	0	5.7	0	4.4	0
Almodôvar	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	0
Alpiarça	6.5	0	3.4	0	5.6	0	2.3	0	5.6	0	4.4	0
Alter do Chão	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Alvaiázere	6.3	0	3.4	0	5.4	0	2.3	0	5.3	0	4.4	0
Alvito	5.5	0	3.4	0	4.7	0	2.3	0	4.4	0	4.4	0
Amadora	19.7	0	3.4	6	16.9	0	2.3	4	29.9	0	4.4	8
Amarante	5.8	0	3.4	1	4.9	0	2.3	1	4.6	0	4.4	2
Amares	5.9	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Anadia	6.4	0	3.4	0	5.4	0	2.3	0	5.4	0	4.4	1
Angra do Heroísmo	4.4	0	3.4	1	3.8	0	2.3	0	3.1	0	4.4	1
Ansião	6.4	0	3.4	0	5.5	0	2.3	0	5.4	0	4.4	0
Arcos de Valdevez	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0
Arganil	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0
Armamar	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0
Arouca	6.0	0	3.4	0	5.1	0	2.3	0	5.0	0	4.4	0
Arraiolos	5.7	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0
Arronches	5.0	0	3.4	0	4.3	0	2.3	0	3.8	0	4.4	0
Arruda dos Vinhos	17.5	0	3.4	0	15.0	0	2.3	0	25.0	0	4.4	0
Aveiro	6.6	0	3.4	2	5.6	0	2.3	1	5.7	0	4.4	3
Avis	5.6	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0
Azambuja	14.4	0	3.4	0	12.3	0	2.3	0	18.5	0	4.4	0
Baião	5.7	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Barcelos	6.3	0	3.4	3	5.4	0	2.3	2	5.3	0	4.4	5
Barrancos	4.6	0	3.4	0	3.9	0	2.3	0	3.3	0	4.4	0
Barreiro	16.2	0	3.4	2	13.8	0	2.3	1	22.2	0	4.4	3

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Batalha	14.7	0	3.4	0	12.6	0	2.3	0	19.2	0	4.4	0
Beja	5.3	0	3.4	1	4.5	0	2.3	0	4.1	0	4.4	1
Belmonte	5.1	0	3.4	0	4.4	0	2.3	0	3.9	0	4.4	0
Benavente	6.8	0	3.4	1	5.8	0	2.3	0	6.0	0	4.4	1
Bombarral	20.0	0	3.4	0	17.1	0	2.3	0	30.5	0	4.4	0
Borba	5.1	0	3.4	0	4.4	0	2.3	0	3.9	0	4.4	0
Boticas	5.2	0	3.4	0	4.4	0	2.3	0	4.0	0	4.4	0
Braga	6.0	0	3.4	6	5.2	0	2.3	4	5.0	0	4.4	7
Bragança	4.4	0	3.4	1	3.8	0	2.3	0	3.1	0	4.4	1
Cabeceiras de Basto	5.6	0	3.4	0	4.8	0	2.3	0	4.4	0	4.4	0
Cadaval	18.8	0	3.4	0	16.1	0	2.3	0	27.8	0	4.4	0
Caldas da Rainha	19.9	0	3.4	1	17.0	0	2.3	1	30.3	0	4.4	2
Calheta (Açores)	3.9	0	3.4	0	3.3	0	2.3	0	2.6	0	4.4	0
Calheta (Madeira)	5.8	0	3.4	0	5.0	0	2.3	0	4.7	0	4.4	0
Câmara de Lobos	5.7	0	3.4	1	4.9	0	2.3	0	4.6	0	4.4	1
Caminha	6.4	0	3.4	0	5.5	0	2.3	0	5.5	0	4.4	0
Campo Maior	4.8	0	3.4	0	4.1	0	2.3	0	3.5	0	4.4	0
Cantanhede	6.6	0	3.4	1	5.6	0	2.3	0	5.7	0	4.4	1
Carrazeda de Ansiães	5.0	0	3.4	0	4.3	0	2.3	0	3.7	0	4.4	0
Carregal do Sal	5.8	0	3.4	0	5.0	0	2.3	0	4.7	0	4.4	0
Cartaxo	6.8	0	3.4	0	5.8	0	2.3	0	6.0	0	4.4	1
Cascais	23.4	0	3.4	7	20.0	0	2.3	4	38.8	0	4.4	9

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Castanheira de Pêra	6.1	0	3.4	0	5.2	0	2.3	0	5.1	0	4.4	0
Castelo Branco	5.3	0	3.4	1	4.5	0	2.3	1	4.1	0	4.4	2
Castelo de Paiva	6.0	0	3.4	0	5.1	0	2.3	0	5.0	0	4.4	0
Castelo de Vide	5.2	0	3.4	0	4.5	0	2.3	0	4.0	0	4.4	0
Castro Daire	5.7	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0
Castro Marim	4.6	0	3.4	0	4.0	0	2.3	0	3.4	0	4.4	0
Castro Verde	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0
Celorico da Beira	5.2	0	3.4	0	4.4	0	2.3	0	3.9	0	4.4	0
Celorico de Basto	5.6	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0
Chamusca	6.4	0	3.4	0	5.5	0	2.3	0	5.5	0	4.4	0
Chaves	5.0	0	3.4	1	4.3	0	2.3	0	3.8	0	4.4	1
Cinfães	5.8	0	3.4	0	5.0	0	2.3	0	4.7	0	4.4	0
Coimbra	6.4	0	3.4	4	5.4	0	2.3	3	5.4	0	4.4	5
Condeixa-a-Nova	6.5	0	3.4	0	5.5	0	2.3	0	5.5	0	4.4	0
Constância	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Coruche	6.4	0	3.4	0	5.4	0	2.3	0	5.4	0	4.4	0
Corvo	2.6	0	3.4	0	2.2	0	2.3	0	1.4	0	4.4	0
Covilhã	5.3	0	3.4	1	4.5	0	2.3	1	4.1	0	4.4	2
Crato	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0
Cuba	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0
Elvas	4.9	0	3.4	0	4.2	0	2.3	0	3.6	0	4.4	0
Entroncamento	6.4	0	3.4	0	5.5	0	2.3	0	5.5	0	4.4	0

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Espinho	6.5	0	3.4	0	5.6	0	2.3	0	5.6	0	4.4	1
Esposende	6.5	0	3.4	1	5.5	0	2.3	0	5.6	0	4.4	1
Estarreja	6.5	0	3.4	0	5.5	0	2.3	0	5.6	0	4.4	1
Estremoz	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	0
Évora	5.5	0	3.4	1	4.7	0	2.3	1	4.4	0	4.4	2
Fafe	5.8	0	3.4	1	4.9	0	2.3	1	4.7	0	4.4	2
Faro	5.0	0	3.4	2	4.2	0	2.3	1	3.7	0	4.4	2
Felgueiras	5.8	0	3.4	1	5.0	0	2.3	1	4.8	0	4.4	2
Ferreira do Alentejo	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Ferreira do Zêzere	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Figueira da Foz	15.2	0	3.4	1	13.0	0	2.3	1	20.3	0	4.4	2
Figueira de Castelo Rodrigo	4.7	0	3.4	0	4.0	0	2.3	0	3.5	0	4.4	0
Figueiró dos Vinhos	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Fornos de Algodres	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	0
Freixo de Espada à Cinta	4.6	0	3.4	0	3.9	0	2.3	0	3.3	0	4.4	0
Fronteira	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0
Funchal	5.7	0	3.4	3	4.9	0	2.3	2	4.6	0	4.4	4
Fundão	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	1
Gavião	5.7	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Góis	6.0	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Golegã	6.4	0	3.4	0	5.5	0	2.3	0	5.5	0	4.4	0
Gondomar	6.3	0	3.4	5	5.4	0	2.3	3	5.4	0	4.4	7

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Gouveia	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0
Grândola	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Guarda	5.1	0	3.4	1	4.3	0	2.3	0	3.8	0	4.4	1
Guimarães	5.9	0	3.4	5	5.1	0	2.3	3	4.9	0	4.4	6
Horta	3.5	0	3.4	0	3.0	0	2.3	0	2.2	0	4.4	0
Idanha-a-Nova	5.0	0	3.4	0	4.3	0	2.3	0	3.8	0	4.4	0
Ílhavo	6.7	0	3.4	1	5.7	0	2.3	0	5.8	0	4.4	1
Lagoa (Açores)	5.7	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Lagoa (Faro)	5.5	0	3.4	0	4.7	0	2.3	0	4.4	0	4.4	0
Lagos	5.7	0	3.4	1	4.9	0	2.3	0	4.6	0	4.4	1
Lajes das Flores	2.5	0	3.4	0	2.1	0	2.3	0	1.3	0	4.4	0
Lajes do Pico	4.6	0	3.4	0	3.9	0	2.3	0	3.3	0	4.4	0
Lamego	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	1
Leiria	14.4	0	3.4	4	12.3	0	2.3	2	18.7	0	4.4	5
Lisboa	17.5	0	3.4	17	14.9	0	2.3	11	24.9	0	4.4	22
Loulé	5.1	0	3.4	2	4.3	0	2.3	1	3.9	0	4.4	3
Loures	18.6	0	3.4	7	15.9	0	2.3	4	27.4	0	4.4	9
Lourinhã	23.4	0	3.4	0	20.0	0	2.3	0	38.8	0	4.4	1
Lousã	6.1	0	3.4	0	5.2	0	2.3	0	5.1	0	4.4	0
Lousada	6.0	0	3.4	1	5.1	0	2.3	1	4.9	0	4.4	2
Mação	5.8	0	3.4	0	5.0	0	2.3	0	4.7	0	4.4	0
Macedo de Cavaleiros	4.6	0	3.4	0	4.0	0	2.3	0	3.3	0	4.4	0

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Machico	5.8	0	3.4	0	5.0	0	2.3	0	4.7	0	4.4	0
Madalena	3.6	0	3.4	0	3.0	0	2.3	0	2.3	0	4.4	0
Mafra	22.5	0	3.4	2	19.2	0	2.3	1	36.5	0	4.4	3
Maia	6.4	0	3.4	4	5.5	0	2.3	3	5.5	0	4.4	6
Mangualde	5.5	0	3.4	0	4.7	0	2.3	0	4.4	0	4.4	0
Manteigas	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	0
Marco de Canaveses	5.9	0	3.4	1	5.0	0	2.3	1	4.8	0	4.4	2
Marinha Grande	16.5	0	3.4	1	14.1	0	2.3	0	22.8	0	4.4	1
Marvão	5.1	0	3.4	0	4.4	0	2.3	0	3.9	0	4.4	0
Matosinhos	6.5	0	3.4	5	5.6	0	2.3	4	5.6	0	4.4	7
Mealhada	6.4	0	3.4	0	5.4	0	2.3	0	5.4	0	4.4	0
Mêda	5.0	0	3.4	0	4.3	0	2.3	0	3.7	0	4.4	0
Melgaço	5.6	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0
Mértola	5.0	0	3.4	0	4.2	0	2.3	0	3.7	0	4.4	0
Mesão Frio	5.6	0	3.4	0	4.7	0	2.3	0	4.4	0	4.4	0
Mira	6.8	0	3.4	0	5.8	0	2.3	0	6.0	0	4.4	0
Miranda do Corvo	6.3	0	3.4	0	5.3	0	2.3	0	5.3	0	4.4	0
Miranda do Douro	4.1	0	3.4	0	3.5	0	2.3	0	2.8	0	4.4	0
Mirandela	4.8	0	3.4	0	4.1	0	2.3	0	3.6	0	4.4	0
Mogadouro	4.5	0	3.4	0	3.8	0	2.3	0	3.2	0	4.4	0
Moimenta da Beira	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	0
Moita	14.8	0	3.4	2	12.7	0	2.3	1	19.5	0	4.4	2

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Monção	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0
Monchique	5.7	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Mondim de Basto	5.6	0	3.4	0	4.8	0	2.3	0	4.4	0	4.4	0
Monforte	5.2	0	3.4	0	4.4	0	2.3	0	3.9	0	4.4	0
Montalegre	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	0
Montemor-o-Novo	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0
Montemor-o-Velho	6.7	0	3.4	0	5.7	0	2.3	0	5.9	0	4.4	1
Montijo	14.8	0	3.4	1	12.7	0	2.3	1	19.4	0	4.4	2
Mora	5.9	0	3.4	0	5.1	0	2.3	0	4.8	0	4.4	0
Mortágua	6.1	0	3.4	0	5.2	0	2.3	0	5.1	0	4.4	0
Moura	5.0	0	3.4	0	4.2	0	2.3	0	3.7	0	4.4	0
Mourão	4.9	0	3.4	0	4.2	0	2.3	0	3.7	0	4.4	0
Murça	5.1	0	3.4	0	4.3	0	2.3	0	3.8	0	4.4	0
Murtosa	6.6	0	3.4	0	5.6	0	2.3	0	5.7	0	4.4	0
Nazaré	18.8	0	3.4	0	16.1	0	2.3	0	27.9	0	4.4	0
Nelas	5.6	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0
Nisa	5.4	0	3.4	0	4.6	0	2.3	0	4.3	0	4.4	0
Nordeste	6.3	0	3.4	0	5.3	0	2.3	0	5.3	0	4.4	0
Óbidos	20.2	0	3.4	0	17.3	0	2.3	0	31.0	0	4.4	0
Odemira	6.0	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	1
Odivelas	18.8	0	3.4	5	16.1	0	2.3	3	27.9	0	4.4	7
Oeiras	20.8	0	3.4	5	17.8	0	2.3	4	32.5	0	4.4	7

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Oleiros	5.7	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Olhão	4.9	0	3.4	1	4.2	0	2.3	1	3.6	0	4.4	1
Oliveira de Azeméis	6.3	0	3.4	2	5.4	0	2.3	1	5.4	0	4.4	2
Oliveira de Frades	6.0	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Oliveira do Bairro	6.4	0	3.4	0	5.5	0	2.3	0	5.5	0	4.4	1
Oliveira do Hospital	5.7	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0
Ourém	6.6	0	3.4	1	5.6	0	2.3	1	5.7	0	4.4	1
Ourique	5.5	0	3.4	0	4.7	0	2.3	0	4.4	0	4.4	0
Ovar	6.5	0	3.4	1	5.6	0	2.3	1	5.6	0	4.4	2
Paços de Ferreira	6.1	0	3.4	1	5.2	0	2.3	1	5.1	0	4.4	2
Palmela	6.8	0	3.4	2	5.8	0	2.3	1	6.0	0	4.4	2
Pampilhosa da Serra	5.8	0	3.4	0	4.9	0	2.3	0	4.7	0	4.4	0
Paredes	6.1	0	3.4	2	5.2	0	2.3	1	5.0	0	4.4	3
Paredes de Coura	6.1	0	3.4	0	5.2	0	2.3	0	5.0	0	4.4	0
Pedrógão Grande	6.0	0	3.4	0	5.1	0	2.3	0	5.0	0	4.4	0
Penacova	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Penafiel	6.0	0	3.4	2	5.1	0	2.3	1	4.9	0	4.4	3
Penalva do Castelo	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Penamacor	5.0	0	3.4	0	4.2	0	2.3	0	3.7	0	4.4	0
Penedono	5.1	0	3.4	0	4.4	0	2.3	0	3.9	0	4.4	0
Penela	6.3	0	3.4	0	5.4	0	2.3	0	5.4	0	4.4	0
Peniche	25.4	0	3.4	0	21.7	0	2.3	0	43.9	0	4.4	1

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Peso da Régua	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Pinhel	4.8	0	3.4	0	4.1	0	2.3	0	3.6	0	4.4	0
Pombal	6.7	0	3.4	1	5.7	0	2.3	1	5.8	0	4.4	2
Ponta Delgada	5.6	0	3.4	2	4.8	0	2.3	1	4.4	0	4.4	2
Ponta do Sol	5.8	0	3.4	0	4.9	0	2.3	0	4.7	0	4.4	0
Ponte da Barca	5.9	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Ponte de Lima	6.1	0	3.4	1	5.2	0	2.3	0	5.1	0	4.4	1
Ponte de Sôr	5.8	0	3.4	0	4.9	0	2.3	0	4.7	0	4.4	0
Portalegre	5.2	0	3.4	0	4.4	0	2.3	0	4.0	0	4.4	0
Portel	5.2	0	3.4	0	4.5	0	2.3	0	4.0	0	4.4	0
Portimão	5.6	0	3.4	1	4.8	0	2.3	1	4.5	0	4.4	2
Porto	6.4	0	3.4	7	5.5	0	2.3	5	5.5	0	4.4	9
Porto de Mós	14.5	0	3.4	0	12.4	0	2.3	0	18.9	0	4.4	1
Porto Moniz	6.1	0	3.4	0	5.2	0	2.3	0	5.0	0	4.4	0
Porto Santo	6.4	0	3.4	0	5.4	0	2.3	0	5.4	0	4.4	0
Póvoa de Lanhoso	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0
Póvoa de Varzim	6.5	0	3.4	2	5.6	0	2.3	1	5.6	0	4.4	2
Povoação	6.1	0	3.4	0	5.2	0	2.3	0	5.1	0	4.4	0
Proença-a-Nova	5.8	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Redondo	5.2	0	3.4	0	4.4	0	2.3	0	4.0	0	4.4	0
Reguengos de Monsaraz	5.1	0	3.4	0	4.4	0	2.3	0	3.9	0	4.4	0
Resende	5.7	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Ribeira Brava	5.8	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Ribeira de Pena	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0
Ribeira Grande	5.8	0	3.4	1	4.9	0	2.3	0	4.7	0	4.4	1
Rio Maior	16.1	0	3.4	0	13.7	0	2.3	0	22.0	0	4.4	0
Sabrosa	5.2	0	3.4	0	4.5	0	2.3	0	4.0	0	4.4	0
Sabugal	4.9	0	3.4	0	4.2	0	2.3	0	3.6	0	4.4	0
Salvaterra de Magos	6.8	0	3.4	0	5.8	0	2.3	0	6.0	0	4.4	0
Santa Comba Dão	6.0	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Santa Cruz	5.8	0	3.4	1	4.9	0	2.3	1	4.7	0	4.4	1
Santa Cruz da Graciosa	3.9	0	3.4	0	3.4	0	2.3	0	2.6	0	4.4	0
Santa Cruz das Flores	2.5	0	3.4	0	2.2	0	2.3	0	1.3	0	4.4	0
Santa Maria da Feira	6.4	0	3.4	4	5.5	0	2.3	3	5.5	0	4.4	6
Santa Marta de Penaguião	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Santana	6.0	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Santarém	6.7	0	3.4	1	5.7	0	2.3	1	5.8	0	4.4	2
Santiago do Cacém	6.3	0	3.4	0	5.3	0	2.3	0	5.3	0	4.4	1
Santo Tirso	6.2	0	3.4	2	5.3	0	2.3	1	5.2	0	4.4	2
São Brás de Alportel	5.0	0	3.4	0	4.2	0	2.3	0	3.7	0	4.4	0
São João da Madeira	6.4	0	3.4	0	5.4	0	2.3	0	5.4	0	4.4	0
São João da Pesqueira	5.1	0	3.4	0	4.3	0	2.3	0	3.9	0	4.4	0
São Pedro do Sul	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0
São Roque do Pico	5.6	0	3.4	0	4.8	0	2.3	0	4.5	0	4.4	0

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
São Vicente	6.0	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Sardoal	6.0	0	3.4	0	5.1	0	2.3	0	5.0	0	4.4	0
Sátão	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Seia	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Seixal	16.6	0	3.4	5	14.2	0	2.3	3	23.0	0	4.4	7
Sernancelhe	5.2	0	3.4	0	4.4	0	2.3	0	4.0	0	4.4	0
Serpa	5.0	0	3.4	0	4.3	0	2.3	0	3.8	0	4.4	0
Sertã	6.0	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Sesimbra	15.7	0	3.4	1	13.4	0	2.3	1	21.1	0	4.4	2
Setúbal	6.8	0	3.4	3	5.8	0	2.3	2	5.9	0	4.4	5
Sever do Vouga	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Silves	5.5	0	3.4	1	4.7	0	2.3	0	4.4	0	4.4	1
Sines	6.5	0	3.4	0	5.5	0	2.3	0	5.5	0	4.4	0
Sintra	22.9	0	3.4	13	19.6	0	2.3	9	37.7	0	4.4	17
Sobral de Monte Agraço	19.0	0	3.4	0	16.3	0	2.3	0	28.4	0	4.4	0
Soure	6.7	0	3.4	0	5.7	0	2.3	0	5.8	0	4.4	0
Sousel	5.4	0	3.4	0	4.6	0	2.3	0	4.2	0	4.4	0
Tábua	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0
Tabuaço	5.3	0	3.4	0	4.5	0	2.3	0	4.0	0	4.4	0
Tarouca	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Tavira	4.8	0	3.4	0	4.1	0	2.3	0	3.5	0	4.4	1
Terras de Bouro	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Tomar	6.3	0	3.4	1	5.4	0	2.3	0	5.4	0	4.4	1
Tondela	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	1
Torre de Moncorvo	4.8	0	3.4	0	4.1	0	2.3	0	3.5	0	4.4	0
Torres Novas	6.5	0	3.4	1	5.6	0	2.3	0	5.6	0	4.4	1
Torres Vedras	21.5	0	3.4	2	18.4	0	2.3	1	34.2	0	4.4	3
Trancoso	5.1	0	3.4	0	4.3	0	2.3	0	3.9	0	4.4	0
Trofa	6.3	0	3.4	1	5.4	0	2.3	0	5.3	0	4.4	1
Vagos	6.7	0	3.4	0	5.7	0	2.3	0	5.8	0	4.4	0
Vale de Cambra	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Valença	6.1	0	3.4	0	5.2	0	2.3	0	5.1	0	4.4	0
Valongo	6.3	0	3.4	3	5.4	0	2.3	2	5.3	0	4.4	4
Valpaços	4.9	0	3.4	0	4.2	0	2.3	0	3.7	0	4.4	0
Velas	3.8	0	3.4	0	3.2	0	2.3	0	2.4	0	4.4	0
Vendas Novas	6.2	0	3.4	0	5.3	0	2.3	0	5.2	0	4.4	0
Viana do Alentejo	5.6	0	3.4	0	4.7	0	2.3	0	4.4	0	4.4	0
Viana do Castelo	6.5	0	3.4	2	5.5	0	2.3	1	5.6	0	4.4	3
Vidigueira	5.3	0	3.4	0	4.5	0	2.3	0	4.1	0	4.4	0
Vieira do Minho	5.7	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Vila da Praia da Vitória	4.6	0	3.4	0	3.9	0	2.3	0	3.3	0	4.4	0
Vila de Rei	6.0	0	3.4	0	5.1	0	2.3	0	5.0	0	4.4	0
Vila do Bispo	6.0	0	3.4	0	5.1	0	2.3	0	4.9	0	4.4	0
Vila do Conde	6.5	0	3.4	2	5.6	0	2.3	1	5.6	0	4.4	3

Table D.2.3: Medium Asteroid's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-19}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-18}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-25}]$	C_p	V_p $[10^{-5}]$	C_p
Vila do Porto	5.7	0	3.4	0	4.9	0	2.3	0	4.6	0	4.4	0
Vila Flor	4.8	0	3.4	0	4.1	0	2.3	0	3.6	0	4.4	0
Vila Franca de Xira	15.9	0	3.4	4	13.6	0	2.3	3	21.7	0	4.4	6
Vila Franca do Campo	5.8	0	3.4	0	5.0	0	2.3	0	4.7	0	4.4	0
Vila Nova da Barquinha	6.4	0	3.4	0	5.4	0	2.3	0	5.4	0	4.4	0
Vila Nova de Cerveira	6.3	0	3.4	0	5.3	0	2.3	0	5.3	0	4.4	0
Vila Nova de Famalicão	6.2	0	3.4	4	5.3	0	2.3	3	5.2	0	4.4	5
Vila Nova de Foz Côa	4.9	0	3.4	0	4.2	0	2.3	0	3.7	0	4.4	0
Vila Nova de Gaia	6.4	0	3.4	10	5.5	0	2.3	6	5.5	0	4.4	13
Vila Nova de Paiva	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Vila Nova de Poiares	6.2	0	3.4	0	5.2	0	2.3	0	5.1	0	4.4	0
Vila Pouca de Aguiar	5.2	0	3.4	0	4.5	0	2.3	0	4.0	0	4.4	0
Vila Real	5.4	0	3.4	1	4.6	0	2.3	1	4.2	0	4.4	2
Vila Real de Santo António	4.6	0	3.4	0	3.9	0	2.3	0	3.3	0	4.4	0
Vila Velha de Ródão	5.5	0	3.4	0	4.7	0	2.3	0	4.3	0	4.4	0
Vila Verde	6.0	0	3.4	1	5.1	0	2.3	1	5.0	0	4.4	2
Vila Viçosa	5.1	0	3.4	0	4.3	0	2.3	0	3.9	0	4.4	0
Vimioso	4.3	0	3.4	0	3.7	0	2.3	0	3.0	0	4.4	0
Vinhais	4.6	0	3.4	0	3.9	0	2.3	0	3.3	0	4.4	0
Viseu	5.7	0	3.4	3	4.8	0	2.3	2	4.6	0	4.4	4
Vizela	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	1
Vouzela	5.9	0	3.4	0	5.0	0	2.3	0	4.8	0	4.4	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Abrantes	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Águeda	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Aguiar da Beira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alandroal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Albergaria-a-Velha	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Albufeira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alcácer do Sal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alcanena	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alcobaça	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alcochete	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alcoutim	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alenquer	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alfândega da Fé	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alijó	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Aljezur	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Aljustrel	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Almada	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Almeida	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Almeirim	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Almodôvar	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alpiarça	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alter do Chão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Alvaiázere	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Alvito	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Amadora	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Amarante	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Amares	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Anadia	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Angra do Heroísmo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ansião	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Arcos de Valdevez	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Arganil	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Armamar	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Arouca	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Arraiolos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Arronches	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Arruda dos Vinhos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Aveiro	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Avis	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Azambuja	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Baião	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Barcelos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Barrancos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Barreiro	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Batalha	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Beja	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Belmonte	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Benavente	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Bombarral	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Borba	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Boticas	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Braga	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Bragança	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Cabeceiras de Basto	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Cadaval	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Caldas da Rainha	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Calheta (Açores)	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Calheta (Madeira)	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Câmara de Lobos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Caminha	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Campo Maior	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Cantanhede	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Carrazeda de Ansiães	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Carregal do Sal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Cartaxo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Cascais	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Castanheira de Pêra	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Castelo Branco	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Castelo de Paiva	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Castelo de Vide	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Castro Daire	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Castro Marim	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Castro Verde	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Celorico da Beira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Celorico de Basto	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Chamusca	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Chaves	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Cinfães	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Coimbra	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Condeixa-a-Nova	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Constância	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Coruche	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Corvo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Covilhã	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Crato	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Cuba	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Elvas	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Entroncamento	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Espinho	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Esposende	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Estarreja	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Estremoz	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Évora	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Fafe	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Faro	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Felgueiras	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ferreira do Alentejo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ferreira do Zêzere	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Figueira da Foz	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Figueira de Castelo Rodrigo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Figueiró dos Vinhos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Fornos de Algodres	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Freixo de Espada à Cinta	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Fronteira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Funchal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Fundão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Gavião	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Góis	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Golegã	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Gondomar	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Gouveia	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Grândola	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Guarda	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Guimarães	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Horta	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Idanha-a-Nova	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ílhavo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lagoa (Açores)	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lagoa (Faro)	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lagos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lajes das Flores	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lajes do Pico	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lamego	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Leiria	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lisboa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Loulé	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Loures	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lourinhã	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lousã	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Lousada	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mação	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Macedo de Cavaleiros	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Machico	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Madalena	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mafra	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Maia	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mangualde	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Manteigas	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Marco de Canaveses	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Marinha Grande	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Marvão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Matosinhos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mealhada	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mêda	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Melgaço	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mértola	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mesão Frio	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Miranda do Corvo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Miranda do Douro	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mirandela	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mogadouro	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Moimenta da Beira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Moita	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Monção	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Monchique	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mondim de Basto	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Monforte	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Montalegre	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Montemor-o-Novo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Montemor-o-Velho	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Montijo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mora	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mortágua	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Moura	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Mourão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Murça	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Murtosa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Nazaré	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Nelas	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Nisa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Nordeste	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Óbidos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Odemira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Odivelas	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Oeiras	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Oleiros	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Olhão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Oliveira de Azeméis	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Oliveira de Frades	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Oliveira do Bairro	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Oliveira do Hospital	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ourém	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ourique	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ovar	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Paços de Ferreira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Palmela	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Pampilhosa da Serra	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Paredes	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Paredes de Coura	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Pedrógão Grande	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Penacova	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Penafiel	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Penalva do Castelo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Penamacor	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Penedono	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Penela	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Peniche	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Peso da Régua	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Pinhel	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Pombal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ponta Delgada	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ponta do Sol	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ponte da Barca	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ponte de Lima	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ponte de Sôr	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Portalegre	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Portel	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Portimão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Porto	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Porto de Mós	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Porto Moniz	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Porto Santo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Póvoa de Lanhoso	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Póvoa de Varzim	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Povoação	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Proença-a-Nova	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Redondo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Reguengos de Monsaraz	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Resende	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Ribeira Brava	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ribeira de Pena	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Ribeira Grande	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Rio Maior	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sabrosa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sabugal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Salvaterra de Magos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santa Comba Dão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santa Cruz	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santa Cruz da Graciosa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santa Cruz das Flores	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santa Maria da Feira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santa Marta de Penaguião	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santana	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santarém	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santiago do Cacém	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Santo Tirso	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
São Brás de Alportel	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
São João da Madeira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
São João da Pesqueira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
São Pedro do Sul	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
São Roque do Pico	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	$V_{\phi+}$	$C_{\phi+}$	$V_{\phi-}$	$C_{\phi-}$	V_e $[10^{-8}]$	C_e	$V_{\phi+}$	$C_{\phi+}$	$V_{\phi-}$	$C_{\phi-}$	V_e $[10^{-10}]$	C_e	$V_{\phi+}$	$C_{\phi+}$	$V_{\phi-}$	$C_{\phi-}$	V_e $[10^{-14}]$	C_e
São Vicente	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sardoal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sátão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Seia	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Seixal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sernancelhe	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Serpa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sertã	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sesimbra	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Setúbal	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sever do Vouga	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Silves	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sines	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sintra	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sobral de Monte Agraço	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Soure	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Sousel	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Tábua	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Tabuaço	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Tarouca	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Tavira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Terras de Bouro	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-}	C_{ϕ^-}	V_e $[10^{-14}]$	C_e
Tomar	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Tondela	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Torre de Moncorvo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Torres Novas	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Torres Vedras	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Trancoso	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Trofa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vagos	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vale de Cambra	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Valença	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Valongo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Valpaços	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Velas	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vendas Novas	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Viana do Alentejo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Viana do Castelo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vidigueira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vieira do Minho	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila da Praia da Vitória	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila de Rei	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila do Bispo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila do Conde	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.4: Medium Asteroid's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
Municipality	$V_{\phi+}$	$C_{\phi+}$	$V_{\phi-}$	$C_{\phi-}$	V_e $[10^{-8}]$	C_e	$V_{\phi+}$	$C_{\phi+}$	$V_{\phi-}$	$C_{\phi-}$	V_e $[10^{-10}]$	C_e	$V_{\phi+}$	$C_{\phi+}$	$V_{\phi-}$	$C_{\phi-}$	V_e $[10^{-14}]$	C_e
Vila do Porto	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Flor	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Franca de Xira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Franca do Campo	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Nova da Barquinha	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Nova de Cerveira	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Nova de Famalicão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Nova de Foz Côa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Nova de Gaia	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Nova de Paiva	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Nova de Poiares	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Pouca de Aguiar	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Real	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Real de Santo António	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Velha de Ródão	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Verde	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vila Viçosa	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vimioso	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vinhais	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Viseu	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vizela	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0
Vouzela	0.0	0	0.0	0	2.2	0	0.0	0	0.0	0	1.9	0	0.0	0	0.0	0	2.6	0

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
1	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
2	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
3	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
4	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
5	0.009	224	0.034	814	0.095	2284	0.008	202	0.030	730	0.086	2067	0.004	100	0.015	351	0.043	1041
6	0.014	557	0.044	1813	0.112	4626	0.012	478	0.038	1573	0.100	4102	0.004	171	0.015	599	0.043	1776
7	0.023	265	0.072	847	0.172	2014	0.018	213	0.059	692	0.146	1705	0.004	49	0.015	172	0.044	510
8	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
9	0.014	772	0.056	2979	0.153	8181	0.012	657	0.047	2513	0.131	7013	0.004	224	0.015	787	0.044	2336
10	0.030	587	0.078	1518	0.162	3166	0.023	456	0.063	1231	0.138	2697	0.004	82	0.015	287	0.044	849
11	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
12	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
13	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
14	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
15	0.020	114	0.072	402	0.181	1014	0.017	93	0.059	329	0.153	854	0.004	23	0.015	82	0.044	243
16	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
17	0.038	6444	0.101	17126	0.208	35085	0.029	4866	0.080	13485	0.173	29178	0.004	719	0.015	2506	0.044	7399
18	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
19	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
20	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
21	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
22	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
23	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
24	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
25	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
26	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
27	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
28	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
29	0.497	16865	0.964	32698	0.995	33741	0.329	11148	0.912	30910	0.986	33428	0.004	148	0.016	533	0.047	1595
30	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
31	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
32	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
33	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
34	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
35	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
36	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
37	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
38	0.014	1063	0.041	3158	0.099	7687	0.012	911	0.036	2769	0.089	6923	0.004	325	0.015	1137	0.043	3364
39	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
40	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
41	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
42	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
43	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
44	0.030	2295	0.080	6015	0.167	12600	0.024	1781	0.064	4863	0.142	10700	0.004	319	0.015	1113	0.044	3287

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
45	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
46	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
47	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
48	0.030	897	0.078	2365	0.165	4984	0.023	698	0.063	1917	0.140	4238	0.004	127	0.015	445	0.044	1316
49	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
50	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
51	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
52	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
53	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
54	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
55	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
56	0.023	1162	0.072	3716	0.172	8847	0.018	935	0.059	3040	0.145	7493	0.004	217	0.015	760	0.044	2249
57	1.000	3204	1.000	3204	1.000	3204	0.999	3202	1.000	3204	1.000	3204	0.005	15	0.018	57	0.054	172
58	1.000	10864	1.000	10864	1.000	10864	1.000	10864	1.000	10864	1.000	10864	0.005	57	0.022	240	0.071	768
59	1.000	33729	1.000	33731	1.000	33731	0.999	33711	1.000	33731	1.000	33731	0.005	170	0.021	703	0.067	2246
60	0.017	266	0.080	1273	0.235	3723	0.014	222	0.065	1029	0.193	3064	0.004	66	0.015	234	0.044	695
61	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
62	0.009	325	0.030	1047	0.079	2759	0.008	293	0.027	953	0.073	2553	0.004	145	0.015	509	0.043	1508
63	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
64	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
65	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
66	0.052	11033	0.195	41510	0.421	89416	0.038	8034	0.145	30751	0.337	71554	0.004	910	0.015	3195	0.045	9467

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
67	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
68	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
69	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
70	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
71	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
72	0.008	50	0.028	173	0.076	478	0.007	46	0.025	159	0.071	444	0.004	25	0.014	90	0.043	269
73	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
74	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
75	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
76	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
77	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
78	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
79	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
80	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
81	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
82	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
83	1.000	64	1.000	64	1.000	64	0.998	64	1.000	64	1.000	64	0.005	0	0.017	1	0.049	3
84	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
85	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
86	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
87	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
88	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
89	0.011	320	0.034	994	0.086	2532	0.010	282	0.030	892	0.079	2318	0.004	122	0.015	428	0.043	1270
90	0.021	720	0.069	2363	0.169	5739	0.017	584	0.057	1942	0.143	4869	0.004	143	0.015	501	0.044	1483
91	0.011	273	0.033	865	0.086	2232	0.009	242	0.030	777	0.079	2043	0.004	108	0.015	377	0.043	1118
92	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
93	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
94	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
95	0.013	771	0.046	2800	0.125	7596	0.011	668	0.040	2417	0.109	6658	0.004	253	0.015	889	0.043	2636
96	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
97	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
98	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
99	0.010	573	0.033	1934	0.088	5203	0.009	513	0.030	1741	0.081	4748	0.004	245	0.015	856	0.043	2538
100	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
101	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
102	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
103	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
104	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
105	1.000	104128	1.000	104128	1.000	104129	1.000	104125	1.000	104128	1.000	104128	0.005	550	0.022	2341	0.073	7564
106	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
107	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
108	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
109	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
110	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
111	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
112	0.019	276	0.065	946	0.163	2371	0.016	227	0.054	783	0.139	2019	0.004	61	0.015	214	0.044	633
113	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
114	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
115	0.100	1455	0.583	8480	0.884	12854	0.068	987	0.438	6367	0.797	11596	0.004	61	0.015	219	0.045	653
116	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
117	0.014	550	0.042	1607	0.100	3856	0.012	469	0.037	1403	0.090	3465	0.004	160	0.015	560	0.043	1658
118	0.314	4609	0.887	13019	0.979	14376	0.200	2936	0.778	11415	0.951	13958	0.004	64	0.016	230	0.047	687
119	0.020	446	0.056	1280	0.130	2947	0.016	365	0.047	1078	0.113	2572	0.004	95	0.015	332	0.043	984
120	0.013	395	0.043	1311	0.112	3394	0.011	341	0.037	1141	0.099	3013	0.004	127	0.015	444	0.043	1315
121	0.986	1443	1.000	1463	1.000	1463	0.953	1394	0.999	1461	1.000	1463	0.004	6	0.016	23	0.048	70
122	0.998	4489	1.000	4497	1.000	4497	0.991	4459	1.000	4497	1.000	4497	0.005	21	0.019	87	0.062	277
123	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
124	0.014	1732	0.050	6295	0.135	16900	0.012	1482	0.043	5373	0.118	14676	0.004	522	0.015	1829	0.043	5423
125	0.031	15585	0.093	47306	0.208	105547	0.024	12080	0.074	37588	0.173	87758	0.004	2151	0.015	7512	0.044	22212
126	0.014	995	0.059	4051	0.165	11387	0.012	847	0.049	3394	0.141	9680	0.004	287	0.015	1008	0.043	2991
127	0.031	6546	0.112	23638	0.266	56211	0.024	5069	0.087	18420	0.217	45823	0.004	896	0.015	3141	0.044	9305
128	0.010	256	0.033	842	0.087	2229	0.009	229	0.030	758	0.079	2039	0.004	107	0.015	373	0.043	1107
129	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
130	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
131	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
132	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
133	0.995	19983	1.000	20093	1.000	20093	0.979	19666	1.000	20093	1.000	20093	0.005	95	0.018	367	0.056	1133
134	0.417	2451	0.998	5865	1.000	5874	0.270	1584	0.994	5838	1.000	5874	0.004	25	0.016	94	0.049	289
135	0.011	916	0.040	3350	0.110	9278	0.010	808	0.035	2943	0.098	8245	0.004	350	0.015	1227	0.043	3640
136	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
137	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
138	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
139	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
140	0.015	580	0.047	1798	0.115	4424	0.013	491	0.040	1548	0.102	3912	0.004	161	0.015	562	0.043	1663
141	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
142	0.013	2265	0.040	7004	0.100	17488	0.011	1955	0.035	6147	0.090	15718	0.004	728	0.015	2544	0.043	7530
143	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
144	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
145	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
146	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
147	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
148	0.009	111	0.029	347	0.076	899	0.008	100	0.027	317	0.071	835	0.004	49	0.015	171	0.043	508
149	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
150	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
151	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
152	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
153	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
154	0.030	1942	0.078	5011	0.162	10435	0.023	1509	0.063	4064	0.138	8891	0.004	273	0.015	952	0.044	2810

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
155	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
156	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
157	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
158	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
159	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
160	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
161	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
162	0.030	1712	0.084	4760	0.180	10259	0.023	1330	0.067	3828	0.152	8645	0.004	241	0.015	840	0.044	2482
163	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
164	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
165	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
166	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
167	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
168	0.015	150	0.041	424	0.098	999	0.012	127	0.036	371	0.088	901	0.004	42	0.015	149	0.043	442
169	0.062	881	0.162	2300	0.307	4353	0.044	629	0.122	1730	0.248	3517	0.004	60	0.015	212	0.044	626
170	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
171	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
172	0.445	2167	0.962	4690	0.995	4852	0.289	1410	0.907	4422	0.986	4809	0.004	21	0.016	78	0.048	234
173	0.039	455	0.114	1337	0.243	2846	0.029	342	0.089	1039	0.199	2335	0.004	49	0.015	174	0.044	515
174	0.014	339	0.053	1316	0.148	3642	0.012	291	0.045	1115	0.127	3132	0.004	102	0.015	360	0.043	1069
175	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
176	0.046	8160	0.130	22860	0.264	46499	0.034	6022	0.100	17548	0.215	37927	0.004	753	0.015	2627	0.044	7758

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
177	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
178	0.009	415	0.034	1495	0.094	4183	0.008	373	0.030	1342	0.085	3790	0.004	185	0.015	647	0.043	1920
179	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
180	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
181	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
182	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
183	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
184	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
185	0.012	638	0.039	2096	0.101	5452	0.010	557	0.034	1848	0.091	4898	0.004	225	0.015	789	0.043	2337
186	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
187	0.032	2036	0.112	7219	0.265	16993	0.024	1572	0.088	5623	0.216	13857	0.004	272	0.015	953	0.044	2822
188	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
189	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
190	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
191	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
192	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
193	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
194	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
195	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
196	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
197	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
198	0.166	4396	0.345	9129	0.514	13610	0.108	2859	0.249	6601	0.413	10942	0.004	115	0.015	403	0.045	1187

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
199	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
200	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
201	0.010	541	0.041	2103	0.117	6028	0.009	480	0.036	1843	0.103	5323	0.004	215	0.015	754	0.043	2239
202	0.187	12674	0.728	49372	0.930	63097	0.121	8181	0.578	39206	0.864	58661	0.004	294	0.015	1046	0.046	3120
203	1.000	8539	1.000	8543	1.000	8543	0.997	8521	1.000	8543	1.000	8543	0.005	42	0.020	167	0.061	522
204	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
205	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
206	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
207	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
208	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
209	0.014	786	0.049	2710	0.128	7078	0.012	670	0.042	2322	0.112	6186	0.004	231	0.015	809	0.043	2399
210	0.012	2573	0.038	8133	0.096	20717	0.010	2244	0.033	7193	0.087	18712	0.004	898	0.015	3137	0.043	9290
211	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
212	1.000	2349	1.000	2349	1.000	2349	0.999	2347	1.000	2349	1.000	2349	0.005	11	0.020	47	0.064	150
213	0.976	5053	0.998	5163	0.999	5171	0.927	4797	0.991	5128	0.997	5161	0.005	24	0.017	86	0.049	255
214	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
215	0.024	1530	0.074	4642	0.171	10679	0.020	1219	0.061	3784	0.145	9048	0.004	263	0.015	920	0.044	2723
216	0.994	5918	1.000	5953	1.000	5953	0.977	5818	1.000	5953	1.000	5953	0.005	28	0.018	106	0.054	321
217	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
218	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
219	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
220	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
221	1.000	12409	1.000	12410	1.000	12410	0.999	12403	1.000	12410	1.000	12410	0.005	62	0.021	255	0.065	809
222	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
223	0.805	26320	0.991	32414	0.999	32657	0.630	20591	0.973	31819	0.996	32556	0.005	147	0.016	532	0.049	1591
224	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
225	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
226	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
227	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
228	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
229	1.000	44741	1.000	44743	1.000	44743	1.000	44725	1.000	44743	1.000	44743	0.005	227	0.020	898	0.063	2800
230	0.588	2483	0.870	3677	0.945	3991	0.402	1700	0.754	3184	0.888	3753	0.004	18	0.015	65	0.045	192
231	1.000	2163	1.000	2163	1.000	2163	0.998	2158	1.000	2163	1.000	2163	0.005	10	0.017	36	0.050	108
232	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
233	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
234	0.919	6203	1.000	6749	1.000	6749	0.804	5428	1.000	6748	1.000	6749	0.005	31	0.018	118	0.054	367
235	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
236	0.019	549	0.068	1942	0.172	4938	0.016	451	0.056	1600	0.146	4181	0.004	120	0.015	422	0.044	1251
237	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
238	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
239	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
240	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
241	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
242	0.998	3257	1.000	3263	1.000	3263	0.991	3234	1.000	3263	1.000	3263	0.005	15	0.020	65	0.064	210

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
243	0.999	5143	1.000	5149	1.000	5149	0.994	5117	1.000	5149	1.000	5149	0.005	25	0.019	99	0.061	312
244	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
245	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
246	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
247	0.031	5092	0.080	13404	0.169	28127	0.024	3950	0.065	10829	0.143	23863	0.004	707	0.015	2464	0.044	7274
248	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
249	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
250	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
251	0.636	32797	0.886	45675	0.949	48951	0.446	22983	0.776	40021	0.896	46212	0.005	232	0.016	816	0.047	2406
252	0.032	3665	0.125	14441	0.304	35136	0.024	2830	0.096	11128	0.245	28406	0.004	490	0.015	1721	0.044	5103
253	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
254	0.018	655	0.067	2417	0.174	6304	0.015	542	0.055	1994	0.147	5331	0.004	151	0.015	530	0.044	1573
255	0.017	237	0.056	769	0.140	1906	0.014	197	0.048	648	0.121	1649	0.004	57	0.015	199	0.043	591
256	0.022	8511	0.088	34107	0.230	89330	0.018	6878	0.070	27282	0.190	73637	0.004	1640	0.015	5755	0.044	17068
257	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
258	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
259	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
260	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
261	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
262	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
263	0.012	290	0.046	1128	0.129	3192	0.010	254	0.039	975	0.113	2786	0.004	102	0.015	360	0.043	1070
264	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
265	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
266	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
267	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
268	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
269	0.010	787	0.036	2822	0.100	7807	0.009	701	0.032	2510	0.090	7021	0.004	326	0.015	1141	0.043	3383
270	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
271	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
272	0.013	303	0.040	899	0.097	2189	0.012	261	0.035	790	0.087	1976	0.004	94	0.015	330	0.043	979
273	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
274	0.010	135	0.044	583	0.132	1759	0.009	120	0.038	506	0.115	1531	0.004	55	0.015	194	0.043	576
275	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
276	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
277	1.000	5136	1.000	5136	1.000	5136	1.000	5136	1.000	5136	1.000	5136	0.005	25	0.019	95	0.056	290
278	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
279	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
280	0.022	1870	0.112	9505	0.316	26730	0.018	1510	0.087	7403	0.255	21564	0.004	356	0.015	1255	0.044	3732
281	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
282	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
283	0.045	952	0.238	5077	0.549	11702	0.033	706	0.174	3713	0.443	9447	0.004	90	0.015	318	0.044	945
284	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
285	0.159	820	0.330	1703	0.497	2559	0.104	535	0.239	1231	0.399	2054	0.004	22	0.015	77	0.044	229
286	0.017	1389	0.056	4461	0.138	10986	0.015	1155	0.047	3760	0.120	9520	0.004	334	0.015	1167	0.043	3454

Table D.2.5: Medium Asteroid's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave						Collapse wave					
	best		expected		worst		best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
287	0.997	5605	1.000	5622	1.000	5622	0.987	5550	0.999	5618	1.000	5621	0.005	27	0.017	96	0.051	286
288	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
289	0.030	4300	0.107	15088	0.252	35649	0.024	3338	0.083	11817	0.206	29177	0.004	600	0.015	2101	0.044	6223
290	0.867	9609	0.996	11037	1.000	11073	0.718	7950	0.987	10936	0.998	11059	0.005	50	0.016	182	0.049	547
291	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
292	0.012	109	0.051	449	0.146	1296	0.011	94	0.043	383	0.126	1116	0.004	37	0.015	129	0.043	385
293	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
294	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
295	0.011	3351	0.038	11252	0.099	29776	0.010	2948	0.033	9961	0.089	26796	0.004	1250	0.015	4371	0.043	12951
296	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
297	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
298	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
299	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
300	0.008	153	0.027	515	0.075	1409	0.007	140	0.025	474	0.070	1312	0.004	78	0.014	273	0.043	810
301	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
302	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
303	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
304	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
305	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
306	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
307	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
308	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

D.3 5km Impactor's impact effects

Table D.3.1 shows 5km Impactor's impact effects results. This includes the seismic shaking, the overpressure, the thermal radiation and the ejecta results. Along with the variables related to each impact effect, the distance to the impact site, the population and the ID for each municipality are also repeated.

Table D.3.2 shows 5km Impactor's tsunami effects simulations. Besides the rim-wave and collapse wave variables, the minimum and maximum altitudes for each municipality are also repeated.

Table D.3.3 shows 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties for all three case scenarios.

Table D.3.4 shows 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties for all three case scenarios.

Table D.3.5 shows 5km Impactor's rim-wave vulnerabilities and casualties for all three case scenarios. This table, instead of listing the municipalities, lists the ID previously associated to each municipality, for space-saving purposes.

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Abrantes	1	35377	750.5	3.8	458.0	31.54	0.836	0.078	4.04	40.42	0.936	6.967
Águeda	2	45992	731.3	3.8	446.3	33.06	0.794	0.109	5.96	59.62	1.003	7.530
Aguiar da Beira	3	4740	809.5	3.7	494.0	27.52	0.973	0.005	0.24	2.42	0.766	5.550
Alandroal	4	5064	829.3	3.7	506.1	26.37	1.021	0.000	0.00	0.00	0.718	5.163
Albergaria-a-Velha	5	24128	729.7	3.8	445.3	33.19	0.790	0.112	6.14	61.36	1.008	7.580
Albufeira	6	41123	808.8	3.7	493.6	27.57	0.971	0.006	0.27	2.67	0.768	5.566
Alcácer do Sal	7	11712	742.0	3.8	452.8	32.19	0.817	0.091	4.85	48.50	0.965	7.208
Alcanena	8	12860	710.4	3.8	433.5	34.85	0.749	0.145	8.42	84.17	1.083	8.214
Alcobaça	9	53641	683.3	4.2	417.0	37.44	0.693	0.194	12.19	121.93	1.200	9.230
Alcochete	10	19505	695.2	4.1	424.3	36.26	0.718	0.172	10.44	104.43	1.146	8.763
Alcoutim	11	2244	857.8	3.7	523.5	24.85	1.092	0.000	0.00	0.00	0.657	4.665
Alenquer	12	43596	685.9	4.2	418.6	37.18	0.698	0.190	11.81	118.06	1.188	9.127
Alfândega da Fé	13	4568	866.1	3.7	528.5	24.43	1.113	0.000	0.00	0.00	0.640	4.533
Alijó	14	10703	822.5	3.7	502.0	26.76	1.004	0.000	0.00	0.00	0.734	5.291
Aljezur	15	5599	753.8	3.8	460.0	31.28	0.844	0.073	3.74	37.40	0.925	6.874
Aljustrel	16	8285	785.9	3.7	479.6	29.02	0.917	0.028	1.35	13.49	0.828	6.066
Almada	17	168987	680.1	4.2	415.1	37.76	0.687	0.200	12.68	126.81	1.215	9.360
Almeida	18	5926	862.0	3.7	526.1	24.63	1.103	0.000	0.00	0.00	0.648	4.597
Almeirim	19	22569	717.4	3.8	437.8	34.23	0.764	0.133	7.55	75.51	1.055	7.976
Almodôvar	20	6746	807.4	3.7	492.8	27.65	0.968	0.007	0.31	3.13	0.771	5.594
Alpiarça	21	7087	719.8	3.8	439.3	34.02	0.769	0.128	7.26	72.65	1.046	7.897
Alter do Chão	22	3191	799.6	3.7	488.0	28.14	0.949	0.014	0.63	6.31	0.791	5.761
Alvaiázere	23	6626	733.3	3.8	447.5	32.89	0.798	0.105	5.74	57.40	0.995	7.467

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Alvito	24	2462	789.4	3.7	481.8	28.79	0.925	0.024	1.15	11.48	0.819	5.986
Amadora	25	181724	671.4	4.2	409.7	38.68	0.669	0.217	14.08	140.82	1.257	9.731
Amarante	26	53366	772.5	3.7	471.4	29.93	0.886	0.046	2.24	22.35	0.867	6.387
Amares	27	18114	759.3	3.8	463.4	30.87	0.856	0.064	3.26	32.65	0.907	6.726
Anadia	28	27298	730.8	3.8	446.0	33.09	0.793	0.110	6.01	60.09	1.004	7.543
Angra do Heroísmo	29	33903	891.2	3.6	543.9	23.24	1.179	0.000	0.00	0.00	0.593	4.159
Ansião	30	12106	728.5	3.8	444.6	33.29	0.788	0.114	6.27	62.67	1.013	7.617
Arcos de Valdevez	31	20970	760.9	3.8	464.4	30.76	0.859	0.062	3.13	31.32	0.902	6.684
Arganil	32	11068	761.6	3.8	464.8	30.71	0.861	0.061	3.08	30.80	0.900	6.667
Armamar	33	5792	801.6	3.7	489.2	28.01	0.954	0.012	0.54	5.42	0.786	5.717
Arouca	34	20861	752.7	3.8	459.4	31.36	0.841	0.074	3.84	38.37	0.929	6.904
Arraiolos	35	6944	779.2	3.7	475.5	29.47	0.901	0.037	1.77	17.75	0.847	6.225
Arronches	36	2860	832.4	3.7	508.0	26.20	1.028	0.000	0.00	0.00	0.711	5.105
Arruda dos Vinhos	37	15082	681.1	4.2	415.7	37.66	0.689	0.198	12.53	125.30	1.210	9.319
Aveiro	38	77916	715.2	3.8	436.5	34.43	0.759	0.137	7.82	78.19	1.063	8.050
Avis	39	4249	781.5	3.7	476.9	29.31	0.907	0.034	1.62	16.22	0.841	6.169
Azambuja	40	22445	697.7	4.1	425.8	36.03	0.723	0.168	10.10	101.02	1.136	8.671
Baião	41	18891	774.2	3.7	472.5	29.81	0.890	0.043	2.11	21.12	0.862	6.345
Barcelos	42	116531	735.5	3.8	448.9	32.71	0.803	0.102	5.51	55.08	0.987	7.400
Barrancos	43	1645	878.8	3.7	536.3	23.82	1.146	0.000	0.00	0.00	0.616	4.339
Barreiro	44	75419	687.7	4.2	419.7	37.00	0.702	0.186	11.54	115.36	1.180	9.055
Batalha	45	15840	695.8	4.1	424.6	36.20	0.719	0.171	10.36	103.62	1.144	8.741
Beja	46	33550	807.1	3.7	492.5	27.68	0.967	0.007	0.33	3.26	0.772	5.602

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Belmonte	47	6407	822.0	3.7	501.6	26.79	1.003	0.000	0.00	0.00	0.735	5.302
Benavente	48	30214	704.3	3.8	429.8	35.41	0.736	0.156	9.21	92.09	1.108	8.430
Bombarral	49	12533	670.3	4.2	409.1	38.79	0.667	0.219	14.26	142.56	1.263	9.777
Borba	50	6790	822.9	3.7	502.2	26.73	1.005	0.000	0.00	0.00	0.733	5.284
Boticas	51	5059	816.2	3.7	498.1	27.13	0.989	0.001	0.06	0.64	0.749	5.416
Braga	52	181919	751.6	3.8	458.7	31.45	0.839	0.076	3.94	39.40	0.932	6.936
Bragança	53	33586	892.5	3.6	544.7	23.18	1.182	0.000	0.00	0.00	0.591	4.141
Cabeceiras de Basto	54	15699	785.6	3.7	479.4	29.04	0.916	0.029	1.37	13.70	0.829	6.074
Cadaval	55	13627	675.3	4.2	412.1	38.26	0.677	0.209	13.45	134.48	1.238	9.563
Caldas da Rainha	56	51540	670.6	4.2	409.3	38.75	0.668	0.218	14.20	142.04	1.261	9.763
Calheta (Açores)	57	3205	960.7	3.6	586.3	20.42	1.369	0.000	0.00	0.00	0.486	3.321
Calheta (Madeira)	58	10865	767.6	3.7	468.5	30.27	0.875	0.052	2.60	25.97	0.882	6.510
Câmara de Lobos	59	33732	773.5	3.7	472.1	29.86	0.888	0.044	2.16	21.60	0.864	6.362
Caminha	60	15873	727.9	3.8	444.3	33.33	0.787	0.114	6.33	63.26	1.015	7.634
Campo Maior	61	7907	852.8	3.7	520.5	25.10	1.079	0.000	0.00	0.00	0.667	4.747
Cantanhede	62	35068	716.5	3.8	437.3	34.31	0.762	0.134	7.65	76.53	1.058	8.004
Carrazeda de Ansiães	63	5683	835.7	3.7	510.0	26.01	1.036	0.000	0.00	0.00	0.704	5.045
Carregal do Sal	64	9290	767.6	3.7	468.4	30.28	0.875	0.052	2.60	26.03	0.882	6.511
Cartaxo	65	23740	703.3	3.8	429.2	35.49	0.734	0.158	9.33	93.31	1.112	8.463
Cascais	66	212474	657.1	4.3	401.0	40.25	0.641	0.244	16.54	165.42	1.331	10.380
Castanheira de Pêra	67	2650	747.7	3.8	456.3	31.75	0.830	0.082	4.30	42.99	0.945	7.044
Castelo Branco	68	52192	809.2	3.7	493.9	27.54	0.972	0.006	0.25	2.51	0.766	5.556
Castelo de Paiva	69	15567	753.4	3.8	459.8	31.32	0.843	0.073	3.78	37.80	0.926	6.887

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Castelo de Vide	70	2951	814.8	3.7	497.2	27.21	0.985	0.002	0.09	0.95	0.753	5.444
Castro Daire	71	13928	778.1	3.7	474.9	29.54	0.899	0.038	1.84	18.43	0.850	6.250
Castro Marim	72	6274	869.8	3.7	530.8	24.25	1.123	0.000	0.00	0.00	0.633	4.475
Castro Verde	73	6946	798.6	3.7	487.4	28.20	0.947	0.015	0.68	6.75	0.794	5.781
Celorico da Beira	74	6978	820.5	3.7	500.7	26.88	0.999	0.000	0.00	0.01	0.739	5.331
Celorico de Basto	75	19075	781.7	3.7	477.0	29.30	0.907	0.034	1.61	16.12	0.840	6.166
Chamusca	76	9253	727.3	3.8	443.9	33.38	0.785	0.115	6.40	63.96	1.017	7.653
Chaves	77	39345	833.4	3.7	508.6	26.14	1.031	0.000	0.00	0.00	0.709	5.087
Cinfães	78	18470	768.0	3.7	468.7	30.25	0.875	0.052	2.57	25.71	0.881	6.501
Coimbra	79	133724	730.5	3.8	445.8	33.12	0.792	0.110	6.05	60.47	1.005	7.554
Condeixa-a-Nova	80	17597	723.4	3.8	441.5	33.71	0.777	0.122	6.84	68.36	1.032	7.777
Constância	81	4002	739.0	3.8	451.0	32.42	0.811	0.096	5.15	51.45	0.975	7.295
Coruche	82	17629	728.7	3.8	444.7	33.27	0.788	0.113	6.24	62.39	1.012	7.609
Corvo	83	65	1211.3	3.4	739.2	13.89	2.174	0.000	0.00	0.00	0.263	1.657
Covilhã	84	47127	808.5	3.7	493.4	27.59	0.970	0.006	0.28	2.77	0.768	5.572
Crato	85	3185	799.6	3.7	488.0	28.14	0.949	0.014	0.63	6.28	0.791	5.759
Cuba	86	4599	800.3	3.7	488.4	28.10	0.951	0.013	0.60	6.00	0.789	5.746
Elvas	87	20706	846.6	3.7	516.7	25.43	1.064	0.000	0.00	0.00	0.680	4.853
Entroncamento	88	21214	727.6	3.8	444.1	33.36	0.786	0.115	6.36	63.61	1.016	7.643
Espinho	89	29484	721.2	3.8	440.1	33.90	0.772	0.126	7.10	70.96	1.040	7.850
Esposende	90	34057	722.0	3.8	440.6	33.83	0.774	0.125	7.00	70.04	1.037	7.824
Estarreja	91	25965	722.8	3.8	441.1	33.76	0.776	0.123	6.91	69.07	1.034	7.797
Estremoz	92	12816	811.0	3.7	495.0	27.44	0.976	0.004	0.20	1.96	0.762	5.520

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Évora	93	52454	789.6	3.7	481.9	28.77	0.926	0.024	1.13	11.34	0.818	5.980
Fafe	94	48271	769.6	3.7	469.7	30.13	0.879	0.050	2.45	24.49	0.876	6.460
Faro	95	60974	837.9	3.7	511.3	25.90	1.042	0.000	0.00	0.00	0.699	5.006
Felgueiras	96	56576	765.5	3.8	467.1	30.43	0.870	0.055	2.77	27.66	0.888	6.565
Ferreira do Alentejo	97	7848	791.7	3.7	483.1	28.64	0.930	0.022	1.02	10.23	0.812	5.935
Ferreira do Zêzere	98	7989	741.2	3.8	452.4	32.25	0.816	0.092	4.93	49.27	0.967	7.231
Figueira da Foz	99	58866	692.7	4.1	422.7	36.50	0.712	0.177	10.80	108.04	1.157	8.859
Figueira de Castelo Rodrigo	100	5652	859.0	3.7	524.2	24.78	1.095	0.000	0.00	0.00	0.654	4.645
Figueiró dos Vinhos	101	5608	742.2	3.8	452.9	32.18	0.818	0.091	4.83	48.32	0.964	7.203
Fornos de Algodres	102	4561	807.8	3.7	493.0	27.63	0.968	0.007	0.30	3.01	0.770	5.587
Freixo de Espada à Cinta	103	3312	874.7	3.7	533.8	24.01	1.135	0.000	0.00	0.00	0.624	4.400
Fronteira	104	2986	802.3	3.7	489.6	27.97	0.955	0.011	0.51	5.13	0.784	5.702
Funchal	105	104129	776.6	3.7	474.0	29.64	0.895	0.040	1.94	19.44	0.855	6.286
Fundão	106	26719	808.2	3.7	493.3	27.60	0.970	0.006	0.28	2.85	0.769	5.577
Gavião	107	3347	773.2	3.7	471.9	29.88	0.887	0.045	2.18	21.84	0.865	6.370
Góis	108	3825	756.6	3.8	461.7	31.08	0.850	0.068	3.50	34.99	0.916	6.800
Golegã	109	5375	726.5	3.8	443.4	33.45	0.783	0.117	6.49	64.91	1.020	7.680
Gondomar	110	165631	732.9	3.8	447.3	32.92	0.797	0.106	5.79	57.88	0.997	7.480
Gouveia	111	12486	802.3	3.7	489.6	27.97	0.955	0.011	0.51	5.13	0.784	5.702
Grândola	112	14570	742.9	3.8	453.4	32.12	0.819	0.090	4.76	47.58	0.961	7.181
Guarda	113	39103	830.1	3.7	506.6	26.32	1.023	0.000	0.00	0.00	0.716	5.147
Guimarães	114	152792	758.9	3.8	463.2	30.90	0.855	0.065	3.30	32.97	0.909	6.736
Horta	115	14542	1014.0	3.5	618.8	18.63	1.525	0.000	0.00	0.00	0.422	2.824

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Idanha-a-Nova	116	8157	830.4	3.7	506.8	26.31	1.023	0.000	0.00	0.00	0.716	5.143
Ílhavo	117	38405	712.8	3.8	435.0	34.64	0.754	0.141	8.11	81.12	1.073	8.131
Lagoa (Açores)	118	14681	776.2	3.7	473.7	29.67	0.894	0.041	1.97	19.73	0.856	6.296
Lagoa (Faro)	119	22748	790.3	3.7	482.3	28.73	0.927	0.023	1.10	10.98	0.816	5.966
Lagos	120	30442	773.8	3.7	472.2	29.84	0.889	0.044	2.14	21.43	0.863	6.356
Lajes das Flores	121	1464	1219.6	3.4	744.3	13.74	2.204	0.000	0.00	0.00	0.258	1.623
Lajes do Pico	122	4498	879.4	3.7	536.7	23.79	1.148	0.000	0.00	0.00	0.615	4.330
Lamego	123	24959	791.6	3.7	483.1	28.65	0.930	0.022	1.03	10.26	0.813	5.936
Leiria	124	124857	697.2	4.1	425.5	36.07	0.722	0.169	10.17	101.69	1.138	8.689
Lisboa	125	507220	681.3	4.2	415.8	37.64	0.689	0.198	12.50	124.95	1.209	9.310
Loulé	126	68873	825.7	3.7	503.9	26.58	1.012	0.000	0.00	0.00	0.727	5.231
Loures	127	211359	676.1	4.2	412.6	38.17	0.679	0.208	13.31	133.15	1.234	9.528
Lourinhã	128	25670	657.1	4.3	401.0	40.25	0.641	0.244	16.53	165.33	1.331	10.378
Lousã	129	17128	744.8	3.8	454.5	31.97	0.823	0.087	4.58	45.77	0.955	7.127
Lousada	130	46790	756.4	3.8	461.6	31.09	0.849	0.069	3.51	35.11	0.917	6.803
Mação	131	6323	767.4	3.7	468.4	30.29	0.874	0.053	2.61	26.12	0.882	6.515
Macedo de Cavaleiros	132	14550	869.9	3.7	530.9	24.24	1.123	0.000	0.00	0.00	0.633	4.473
Machico	133	20094	765.8	3.8	467.4	30.40	0.871	0.055	2.74	27.39	0.887	6.556
Madalena	134	5875	1005.5	3.6	613.6	18.89	1.499	0.000	0.00	0.00	0.431	2.896
Mafra	135	84008	660.5	4.3	403.1	39.87	0.648	0.237	15.93	159.30	1.313	10.219
Maia	136	137727	727.6	3.8	444.1	33.36	0.786	0.115	6.36	63.61	1.016	7.643
Mangualde	137	18618	789.0	3.7	481.5	28.82	0.924	0.025	1.17	11.71	0.820	5.995
Manteigas	138	3037	806.1	3.7	491.9	27.74	0.964	0.008	0.36	3.63	0.775	5.622

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Marco de Canaveses	139	51661	765.3	3.8	467.0	30.44	0.869	0.056	2.78	27.82	0.889	6.571
Marinha Grande	140	38404	686.3	4.2	418.8	37.13	0.699	0.189	11.74	117.38	1.186	9.109
Marvão	141	3054	821.6	3.7	501.4	26.81	1.002	0.000	0.00	0.00	0.736	5.310
Matosinhos	142	174382	720.8	3.8	439.9	33.94	0.771	0.127	7.15	71.45	1.042	7.864
Mealhada	143	19892	729.0	3.8	444.9	33.25	0.789	0.113	6.21	62.13	1.011	7.602
Mêda	144	4617	835.1	3.7	509.6	26.05	1.035	0.000	0.00	0.00	0.705	5.056
Melgaço	145	8144	781.5	3.7	476.9	29.32	0.906	0.034	1.63	16.26	0.841	6.171
Mértola	146	6202	836.0	3.7	510.2	26.00	1.037	0.000	0.00	0.00	0.703	5.039
Mesão Frio	147	3996	787.5	3.7	480.6	28.91	0.921	0.027	1.25	12.54	0.824	6.029
Mira	148	11831	705.1	3.8	430.3	35.33	0.738	0.154	9.10	90.98	1.104	8.400
Miranda do Corvo	149	12687	737.5	3.8	450.1	32.55	0.807	0.099	5.31	53.07	0.980	7.342
Miranda do Douro	150	6877	925.5	3.6	564.8	21.77	1.271	0.000	0.00	0.00	0.537	3.715
Mirandela	151	21808	850.4	3.7	519.0	25.23	1.073	0.000	0.00	0.00	0.672	4.788
Mogadouro	152	8481	886.6	3.6	541.1	23.45	1.166	0.000	0.00	0.00	0.602	4.225
Moimenta da Beira	153	9729	805.7	3.7	491.7	27.76	0.963	0.008	0.38	3.76	0.775	5.630
Moita	154	64526	694.9	4.1	424.1	36.29	0.717	0.173	10.49	104.87	1.148	8.775
Monção	155	17902	762.9	3.8	465.6	30.61	0.864	0.059	2.97	29.71	0.896	6.632
Monchique	156	5182	774.2	3.7	472.5	29.81	0.890	0.043	2.11	21.14	0.862	6.346
Mondim de Basto	157	6985	786.0	3.7	479.7	29.01	0.917	0.028	1.34	13.44	0.828	6.064
Monforte	158	2989	820.4	3.7	500.7	26.88	0.999	0.000	0.00	0.02	0.739	5.333
Montalegre	159	9090	809.8	3.7	494.2	27.51	0.973	0.005	0.23	2.34	0.765	5.545
Montemor-o-Novo	160	15740	761.1	3.8	464.5	30.74	0.860	0.062	3.12	31.18	0.902	6.679
Montemor-o-Velho	161	25230	707.7	3.8	431.9	35.09	0.744	0.150	8.76	87.59	1.093	8.308

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D [km]	M_{eff}	D_1 [$km/kt^{-1/3}$]	P_D [kPa]	h/R_f	f	ϕ^+ [MJ/m^2]	ϕ^- [kJ/m^2]	L_e [mm]	t_e [mm]
Montijo	162	56887	695.1	4.1	424.2	36.27	0.717	0.172	10.46	104.59	1.147	8.767
Mora	163	4188	759.9	3.8	463.7	30.83	0.857	0.063	3.22	32.20	0.906	6.712
Mortágua	164	8856	747.5	3.8	456.2	31.76	0.829	0.082	4.32	43.19	0.946	7.050
Moura	165	13749	838.6	3.7	511.8	25.86	1.044	0.000	0.00	0.00	0.698	4.994
Mourão	166	2456	841.4	3.7	513.5	25.71	1.051	0.000	0.00	0.00	0.691	4.944
Murça	167	5480	826.8	3.7	504.6	26.52	1.014	0.000	0.00	0.00	0.724	5.211
Murtosa	168	10244	717.1	3.8	437.6	34.26	0.763	0.133	7.59	75.89	1.056	7.986
Nazaré	169	14180	675.2	4.2	412.1	38.27	0.677	0.209	13.45	134.54	1.238	9.564
Nelas	170	13030	780.7	3.7	476.5	29.37	0.905	0.035	1.67	16.73	0.843	6.188
Nisa	171	6149	797.3	3.7	486.6	28.28	0.943	0.016	0.74	7.38	0.797	5.811
Nordeste	172	4875	737.6	3.8	450.2	32.54	0.808	0.098	5.29	52.92	0.980	7.337
Óbidos	173	11719	669.5	4.2	408.6	38.88	0.665	0.220	14.40	144.00	1.267	9.815
Odemira	174	24621	756.2	3.8	461.5	31.10	0.849	0.069	3.53	35.31	0.917	6.809
Odivelas	175	159602	675.1	4.2	412.0	38.28	0.677	0.210	13.47	134.73	1.239	9.569
Oeiras	176	176218	666.8	4.3	406.9	39.17	0.660	0.225	14.85	148.51	1.281	9.934
Oleiros	177	5045	773.0	3.7	471.7	29.90	0.887	0.045	2.20	22.00	0.865	6.375
Olhão	178	44607	844.9	3.7	515.7	25.51	1.059	0.000	0.00	0.00	0.684	4.881
Oliveira de Azeméis	179	66113	732.1	3.8	446.8	32.98	0.796	0.107	5.87	58.69	0.999	7.504
Oliveira de Frades	180	9920	755.7	3.8	461.2	31.14	0.848	0.070	3.57	35.72	0.919	6.822
Oliveira do Bairro	181	23944	726.5	3.8	443.3	33.46	0.783	0.117	6.49	64.93	1.020	7.681
Oliveira do Hospital	182	19331	778.7	3.7	475.2	29.50	0.900	0.037	1.80	18.04	0.849	6.236
Ourém	183	44068	715.8	3.8	436.8	34.37	0.761	0.135	7.74	77.40	1.061	8.028
Ourique	184	4653	788.5	3.7	481.2	28.85	0.923	0.025	1.20	11.99	0.821	6.007

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Ovar	185	54120	719.9	3.8	439.4	34.01	0.769	0.128	7.25	72.46	1.045	7.892
Paços de Ferreira	186	56709	748.5	3.8	456.8	31.69	0.832	0.081	4.22	42.24	0.943	7.022
Palmela	187	64214	704.4	3.8	429.9	35.40	0.737	0.156	9.20	91.98	1.107	8.427
Pampilhosa da Serra	188	4052	769.8	3.7	469.8	30.12	0.880	0.049	2.44	24.36	0.875	6.456
Paredes	189	86072	750.6	3.8	458.1	31.52	0.836	0.077	4.03	40.27	0.935	6.962
Paredes de Coura	190	8560	751.0	3.8	458.3	31.50	0.837	0.077	4.00	39.97	0.934	6.953
Pedrógão Grande	191	3429	753.2	3.8	459.7	31.33	0.842	0.074	3.80	37.96	0.927	6.892
Penacova	192	13812	742.4	3.8	453.1	32.16	0.818	0.090	4.81	48.07	0.963	7.195
Penafiel	193	69922	754.7	3.8	460.6	31.22	0.845	0.071	3.66	36.62	0.922	6.850
Penalva do Castelo	194	7175	795.0	3.7	485.2	28.43	0.938	0.018	0.85	8.50	0.803	5.860
Penamacor	195	4831	836.5	3.7	510.5	25.97	1.038	0.000	0.00	0.00	0.702	5.031
Penedono	196	2610	824.4	3.7	503.1	26.65	1.009	0.000	0.00	0.00	0.730	5.255
Penela	197	5439	733.0	3.8	447.3	32.91	0.798	0.106	5.77	57.73	0.996	7.476
Peniche	198	26487	650.3	4.3	396.9	41.04	0.628	0.257	17.78	177.80	1.368	10.707
Peso da Régua	199	15830	794.7	3.7	485.0	28.45	0.937	0.019	0.86	8.64	0.804	5.867
Pinhel	200	8607	849.0	3.7	518.1	25.30	1.070	0.000	0.00	0.00	0.675	4.811
Pombal	201	51684	712.0	3.8	434.5	34.70	0.753	0.142	8.21	82.08	1.076	8.157
Ponta Delgada	202	67864	784.5	3.7	478.8	29.11	0.914	0.030	1.43	14.33	0.832	6.098
Ponta do Sol	203	8544	770.9	3.7	470.5	30.04	0.882	0.048	2.35	23.51	0.872	6.427
Ponte da Barca	204	11210	759.2	3.8	463.3	30.88	0.856	0.064	3.28	32.77	0.908	6.730
Ponte de Lima	205	41499	744.6	3.8	454.4	31.99	0.823	0.087	4.59	45.93	0.956	7.132
Ponte de Sôr	206	15092	768.8	3.7	469.2	30.19	0.877	0.051	2.51	25.07	0.878	6.479
Portalegre	207	22359	818.0	3.7	499.2	27.02	0.993	0.001	0.03	0.31	0.745	5.380

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Portel	208	5870	812.6	3.7	495.9	27.34	0.980	0.003	0.15	1.50	0.758	5.488
Portimão	209	55416	783.2	3.7	478.0	29.20	0.910	0.032	1.52	15.17	0.836	6.130
Porto	210	215284	726.5	3.8	443.4	33.45	0.784	0.117	6.49	64.87	1.020	7.679
Porto de Mós	211	23288	696.6	4.1	425.1	36.12	0.721	0.170	10.25	102.47	1.140	8.710
Porto Moniz	212	2350	750.9	3.8	458.3	31.50	0.837	0.077	4.00	40.02	0.935	6.955
Porto Santo	213	5176	731.2	3.8	446.3	33.06	0.794	0.109	5.96	59.64	1.003	7.531
Póvoa de Lanhoso	214	21446	764.6	3.8	466.6	30.49	0.868	0.057	2.84	28.37	0.891	6.589
Póvoa de Varzim	215	62510	719.4	3.8	439.1	34.05	0.768	0.129	7.31	73.06	1.047	7.908
Povoação	216	5954	748.3	3.8	456.7	31.70	0.831	0.081	4.24	42.41	0.943	7.027
Proença-a-Nova	217	7390	772.5	3.7	471.4	29.93	0.886	0.046	2.24	22.37	0.867	6.388
Redondo	218	6387	818.0	3.7	499.2	27.02	0.993	0.001	0.03	0.30	0.745	5.379
Reguengos de Monsaraz	219	10036	824.0	3.7	502.8	26.67	1.008	0.000	0.00	0.00	0.731	5.264
Resende	220	10241	778.8	3.7	475.3	29.50	0.900	0.037	1.80	17.98	0.848	6.234
Ribeira Brava	221	12411	772.1	3.7	471.2	29.96	0.885	0.046	2.27	22.66	0.868	6.398
Ribeira de Pena	222	6031	800.9	3.7	488.8	28.05	0.952	0.012	0.57	5.70	0.788	5.731
Ribeira Grande	223	32698	768.8	3.7	469.2	30.19	0.877	0.051	2.51	25.07	0.878	6.480
Rio Maior	224	20340	688.3	4.2	420.1	36.93	0.703	0.185	11.44	114.40	1.177	9.029
Sabrosa	225	5917	814.0	3.7	496.8	27.26	0.983	0.003	0.11	1.13	0.755	5.459
Sabugal	226	10748	843.8	3.7	514.9	25.58	1.056	0.000	0.00	0.00	0.686	4.902
Salvaterra de Magos	227	21268	704.7	3.8	430.1	35.37	0.737	0.155	9.15	91.51	1.106	8.414
Santa Comba Dão	228	10506	756.0	3.8	461.4	31.12	0.848	0.069	3.55	35.47	0.918	6.815
Santa Cruz	229	44744	770.5	3.7	470.2	30.07	0.881	0.048	2.38	23.78	0.873	6.436
Santa Cruz da Graciosa	230	4225	952.4	3.6	581.2	20.72	1.346	0.000	0.00	0.00	0.498	3.408

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Santa Cruz das Flores	231	2164	1214.9	3.4	741.4	13.83	2.187	0.000	0.00	0.00	0.261	1.642
Santa Maria da Feira	232	138525	727.5	3.8	444.0	33.37	0.786	0.115	6.38	63.80	1.017	7.649
Santa Marta de Penaguião	233	6649	794.5	3.7	484.9	28.46	0.937	0.019	0.88	8.75	0.805	5.872
Santana	234	6750	757.9	3.8	462.5	30.98	0.853	0.066	3.38	33.84	0.912	6.763
Santarém	235	57398	711.4	3.8	434.1	34.76	0.751	0.143	8.29	82.93	1.079	8.180
Santiago do Cacém	236	28725	737.0	3.8	449.8	32.59	0.806	0.099	5.36	53.55	0.982	7.356
Santo Tirso	237	68221	741.7	3.8	452.7	32.21	0.817	0.092	4.88	48.76	0.966	7.216
São Brás de Alportel	238	10416	835.9	3.7	510.1	26.01	1.037	0.000	0.00	0.00	0.703	5.042
São João da Madeira	239	21761	731.1	3.8	446.2	33.07	0.793	0.109	5.98	59.83	1.003	7.536
São João da Pesqueira	240	7154	826.0	3.7	504.1	26.56	1.013	0.000	0.00	0.00	0.726	5.225
São Pedro do Sul	241	15488	764.6	3.8	466.6	30.49	0.868	0.057	2.84	28.37	0.891	6.589
São Roque do Pico	242	3264	781.1	3.7	476.7	29.34	0.906	0.034	1.65	16.50	0.842	6.179
São Vicente	243	5150	757.7	3.8	462.4	30.99	0.852	0.067	3.40	34.03	0.913	6.769
Sardoal	244	3739	753.3	3.8	459.7	31.32	0.842	0.073	3.79	37.90	0.927	6.890
Sátão	245	11602	792.8	3.7	483.9	28.57	0.933	0.021	0.96	9.61	0.809	5.908
Seia	246	22412	791.9	3.7	483.3	28.63	0.931	0.022	1.01	10.12	0.812	5.930
Seixal	247	166835	685.7	4.2	418.5	37.19	0.698	0.190	11.83	118.29	1.189	9.133
Sernancelhe	248	5384	814.8	3.7	497.3	27.21	0.985	0.002	0.09	0.93	0.753	5.443
Serpa	249	14374	831.6	3.7	507.5	26.24	1.026	0.000	0.00	0.00	0.713	5.121
Sertã	250	14682	757.4	3.8	462.2	31.02	0.851	0.067	3.43	34.31	0.914	6.778
Sesimbra	251	51559	690.4	4.1	421.3	36.73	0.708	0.181	11.13	111.33	1.168	8.947
Setúbal	252	115758	705.3	3.8	430.4	35.31	0.739	0.154	9.07	90.73	1.103	8.393
Sever do Vouga	253	11403	739.6	3.8	451.4	32.38	0.812	0.095	5.08	50.85	0.973	7.277

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Silves	254	36174	789.2	3.7	481.6	28.80	0.924	0.025	1.16	11.59	0.819	5.991
Sines	255	13631	724.3	3.8	442.0	33.64	0.779	0.121	6.74	67.39	1.028	7.750
Sintra	256	388434	658.7	4.3	402.0	40.07	0.644	0.241	16.24	162.45	1.322	10.302
Sobral de Monte Agraço	257	10490	674.3	4.2	411.5	38.37	0.675	0.211	13.61	136.10	1.243	9.606
Soure	258	17277	712.4	3.8	434.8	34.67	0.753	0.141	8.16	81.60	1.074	8.144
Sousel	259	4454	801.6	3.7	489.2	28.01	0.954	0.012	0.54	5.43	0.786	5.718
Tábua	260	11403	764.4	3.8	466.5	30.50	0.867	0.057	2.85	28.49	0.891	6.593
Tabuaço	261	6017	812.0	3.7	495.5	27.38	0.978	0.004	0.17	1.68	0.760	5.501
Tarouca	262	7761	792.6	3.7	483.7	28.58	0.932	0.021	0.97	9.74	0.810	5.914
Tavira	263	24750	856.6	3.7	522.8	24.91	1.089	0.000	0.00	0.00	0.659	4.685
Terras de Bouro	264	6405	765.2	3.8	467.0	30.45	0.869	0.056	2.79	27.90	0.889	6.573
Tomar	265	36902	731.6	3.8	446.5	33.02	0.795	0.108	5.92	59.21	1.001	7.518
Tondela	266	26548	761.3	3.8	464.6	30.73	0.860	0.061	3.10	31.04	0.901	6.675
Torre de Moncorvo	267	7716	855.5	3.7	522.1	24.96	1.086	0.000	0.00	0.00	0.661	4.703
Torres Novas	268	34970	721.3	3.8	440.2	33.89	0.772	0.126	7.09	70.86	1.040	7.847
Torres Vedras	269	78220	664.0	4.3	405.2	39.48	0.655	0.231	15.33	153.29	1.295	10.060
Trancoso	270	8946	825.4	3.7	503.7	26.59	1.011	0.000	0.00	0.00	0.727	5.237
Trofa	271	38317	733.5	3.8	447.7	32.87	0.799	0.105	5.72	57.17	0.994	7.460
Vagos	272	22685	711.1	3.8	434.0	34.79	0.751	0.144	8.33	83.27	1.080	8.190
Vale de Cambra	273	21399	739.1	3.8	451.0	32.42	0.811	0.096	5.14	51.44	0.975	7.294
Valença	274	13283	748.3	3.8	456.7	31.70	0.831	0.081	4.24	42.39	0.943	7.026
Valongo	275	96570	735.7	3.8	449.0	32.69	0.804	0.101	5.49	54.86	0.986	7.394
Valpaços	276	14932	842.9	3.7	514.4	25.62	1.054	0.000	0.00	0.00	0.688	4.916

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Velas	277	5137	975.8	3.6	595.5	19.88	1.412	0.000	0.00	0.00	0.467	3.169
Vendas Novas	278	11259	739.7	3.8	451.4	32.37	0.812	0.095	5.08	50.77	0.972	7.275
Viana do Alentejo	279	5142	786.3	3.7	479.8	29.00	0.918	0.028	1.33	13.29	0.827	6.058
Viana do Castelo	280	84636	722.5	3.8	440.9	33.79	0.775	0.124	6.95	69.45	1.035	7.808
Vidigueira	281	5498	806.8	3.7	492.4	27.69	0.966	0.007	0.33	3.35	0.773	5.606
Vieira do Minho	282	11898	776.2	3.7	473.7	29.68	0.894	0.041	1.97	19.75	0.856	6.297
Vila da Praia da Vitória	283	21331	876.7	3.7	535.0	23.92	1.140	0.000	0.00	0.00	0.620	4.371
Vila de Rei	284	3321	753.8	3.8	460.0	31.28	0.843	0.073	3.74	37.41	0.925	6.875
Vila do Bispo	285	5154	755.4	3.8	461.0	31.16	0.847	0.070	3.60	35.99	0.920	6.831
Vila do Conde	286	79579	720.4	3.8	439.6	33.97	0.770	0.127	7.20	71.96	1.043	7.878
Vila do Porto	287	5623	773.1	3.7	471.8	29.89	0.887	0.045	2.19	21.93	0.865	6.373
Vila Flor	288	6073	849.6	3.7	518.5	25.27	1.071	0.000	0.00	0.00	0.674	4.802
Vila Franca de Xira	289	141603	689.1	4.2	420.5	36.86	0.705	0.184	11.33	113.27	1.174	8.999
Vila Franca do Campo	290	11078	765.8	3.8	467.3	30.41	0.870	0.055	2.74	27.42	0.887	6.557
Vila Nova da Barquinha	291	7402	730.6	3.8	445.9	33.11	0.792	0.110	6.03	60.32	1.005	7.550
Vila Nova de Cerveira	292	8877	737.7	3.8	450.2	32.53	0.808	0.098	5.29	52.85	0.980	7.336
Vila Nova de Famalicão	293	131738	739.6	3.8	451.4	32.38	0.812	0.095	5.09	50.88	0.973	7.278
Vila Nova de Foz Côa	294	6541	841.9	3.7	513.8	25.68	1.052	0.000	0.00	0.00	0.690	4.934
Vila Nova de Gaia	295	299938	725.6	3.8	442.8	33.52	0.782	0.118	6.58	65.84	1.023	7.706
Vila Nova de Paiva	296	4723	794.7	3.7	485.0	28.45	0.937	0.019	0.87	8.67	0.804	5.868
Vila Nova de Poiares	297	6929	744.1	3.8	454.1	32.02	0.822	0.088	4.64	46.41	0.957	7.147
Vila Pouca de Aguiar	298	12009	813.4	3.7	496.4	27.29	0.982	0.003	0.13	1.30	0.756	5.472
Vila Real	299	49868	800.9	3.7	488.7	28.06	0.952	0.013	0.57	5.74	0.788	5.733

Table D.3.1: 5km Impactor's seismic shaking, overpressure, thermal radiation and ejecta impact effects for studied all municipalities (continuation)

Municipality	ID	Population	D $[km]$	M_{eff}	D_1 $[km/kt^{-1/3}]$	P_D $[kPa]$	h/R_f	f	ϕ^+ $[MJ/m^2]$	ϕ^- $[kJ/m^2]$	L_e $[mm]$	t_e $[mm]$
Vila Real de Santo António	300	18888	872.9	3.7	532.7	24.10	1.131	0.000	0.00	0.00	0.627	4.427
Vila Velha de Ródão	301	3167	792.0	3.7	483.3	28.62	0.931	0.022	1.01	10.07	0.812	5.928
Vila Verde	302	46865	752.9	3.8	459.5	31.35	0.841	0.074	3.83	38.26	0.928	6.901
Vila Viçosa	303	7719	826.6	3.7	504.4	26.53	1.014	0.000	0.00	0.00	0.725	5.214
Vimioso	304	4070	906.3	3.6	553.1	22.57	1.219	0.000	0.00	0.00	0.568	3.955
Vinhais	305	7847	873.2	3.7	532.9	24.08	1.131	0.000	0.00	0.00	0.627	4.422
Viseu	306	96991	777.1	3.7	474.2	29.61	0.896	0.039	1.91	19.13	0.853	6.275
Vizela	307	23840	760.3	3.8	464.0	30.80	0.858	0.063	3.18	31.84	0.904	6.700
Vouzela	308	9661	760.8	3.8	464.3	30.77	0.859	0.062	3.14	31.42	0.903	6.687

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities

Municipality				Rumpf Rim-wave			Collins Rim-wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
Abrantes	127.0	18	317	207.7	42.6	58.2	237.3	45.6	62.2
Águeda	79.0	4	762	198.5	65.9	128.0	226.8	70.4	136.8
Aguiar da Beira	149.0	450	989	196.0	53.9	77.2	224.0	57.7	82.5
Alandroal	159.0	111	416	193.2	36.6	48.8	220.7	39.1	52.2
Albergaria-a-Velha	74.0	0	425	197.5	69.8	106.8	225.7	74.6	114.2
Albufeira	47.0	0	227	170.0	101.9	130.8	194.2	109.0	139.9
Alcácer do Sal	34.0	0	254	182.9	146.2	192.6	209.0	156.2	205.8
Alcanena	85.0	43	678	207.0	65.5	114.9	236.6	70.1	122.8
Alcobaça	49.0	0	504	204.1	107.1	174.6	233.3	114.5	186.7
Alcochete	30.0	0	61	194.6	170.9	183.9	222.4	182.7	196.6
Alcoutim	112.0	25	379	173.6	44.6	63.7	198.4	47.7	68.1
Alenquer	106.0	2	666	223.3	51.9	94.9	255.2	55.5	101.5
Alfândega da Fé	188.0	150	1199	191.0	32.1	67.5	218.2	34.3	72.1
Alijó	146.0	75	1000	191.4	38.1	78.3	218.7	40.7	83.7
Aljezur	36.0	0	370	180.4	137.1	200.5	206.1	146.5	214.3
Aljustrel	110.0	63	258	191.6	49.9	61.1	218.9	53.3	65.4
Almada	27.0	0	125	198.2	191.6	221.6	226.5	204.8	236.8
Almeida	204.0	500	845	196.8	41.1	52.0	224.9	43.9	55.5
Almeirim	119.0	5	171	216.4	45.7	55.1	247.3	48.9	58.9
Almodôvar	115.0	150	577	187.0	51.9	75.2	213.7	55.5	80.4
Alpiarça	126.0	9	132	218.1	43.5	50.2	249.2	46.6	53.6
Alter do Chão	162.0	147	413	203.1	38.3	49.0	232.1	40.9	52.4

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$
Alvaiázere	110.0	96	618	207.7	53.9	85.3	237.4	57.6	91.2
Alvito	100.0	100	315	187.8	56.7	70.2	214.6	60.6	75.0
Amadora	40.0	50	258	205.1	139.8	174.0	234.3	149.4	186.0
Amarante	101.0	50	1348	192.8	53.7	135.6	220.3	57.4	145.0
Amares	79.0	24	901	190.3	66.1	136.4	217.5	70.7	145.8
Anadia	101.0	13	525	205.6	53.0	86.4	234.9	56.7	92.4
Angra do Heroísmo	9.6	0	1021	146.9	463.8	1055.8	167.8	495.8	1128.7
Ansião	110.0	175	533	209.4	58.9	80.5	239.2	63.0	86.1
Arcos de Valdevez	81.0	17	1416	190.4	63.9	173.4	217.6	68.3	185.4
Arganil	148.0	75	1418	211.0	39.4	100.0	241.2	42.2	106.9
Armamar	140.0	75	955	195.7	40.2	80.5	223.6	42.9	86.1
Arouca	96.0	50	1222	197.2	57.1	135.8	225.3	61.0	145.2
Arraiolos	158.0	150	412	208.4	39.9	50.9	238.2	42.6	54.4
Arronches	205.0	236	584	206.4	33.3	44.5	235.8	35.6	47.6
Arruda dos Vinhos	98.0	44	395	222.1	58.9	83.5	253.7	63.0	89.2
Aveiro	50.0	0	78	194.7	102.5	112.5	222.4	109.6	120.3
Avis	152.0	75	245	205.7	37.9	45.3	235.0	40.5	48.4
Azambuja	118.0	2	194	223.4	46.7	57.8	255.2	49.9	61.8
Baião	110.0	50	1416	194.9	49.6	129.2	222.8	53.0	138.1
Barcelos	52.0	9	488	189.4	98.3	156.6	216.5	105.1	167.4
Barrancos	203.0	125	412	191.6	29.0	38.0	218.9	31.0	40.6
Barreiro	30.0	0	76	196.9	171.9	188.2	225.0	183.7	201.2

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$
Batalha	50.0	50	523	200.5	110.6	172.1	229.1	118.2	184.0
Beja	127.0	25	284	190.4	41.2	54.1	217.6	44.0	57.8
Belmonte	203.0	446	890	209.2	40.8	55.3	239.0	43.6	59.1
Benavente	30.0	0	78	192.0	169.7	186.3	219.4	181.4	199.1
Bombarral	90.0	11	205	223.1	61.8	76.6	255.0	66.1	81.9
Borba	163.0	250	550	196.2	41.4	53.3	224.2	44.3	57.0
Boticas	134.0	250	1270	189.8	49.6	97.8	216.9	53.0	104.5
Braga	70.0	22	572	190.0	74.3	124.1	217.1	79.5	132.6
Bragança	220.0	325	1489	192.5	32.6	66.3	220.0	34.8	70.9
Cabeceiras de Basto	105.0	150	1200	190.3	57.3	120.7	217.4	61.3	129.0
Cadaval	94.0	46	665	222.8	61.7	106.8	254.5	66.0	114.2
Caldas da Rainha	36.0	0	255	204.0	145.8	192.3	233.1	155.8	205.5
Calheta (Açores)	3.5	0	942	135.3	1221.0	2658.8	154.6	1305.3	2842.2
Calheta (Madeira)	3.1	0	1640	169.4	1542.5	4704.7	193.5	1648.9	5029.3
Câmara de Lobos	3.8	0	1862	168.2	1254.1	4173.1	192.2	1340.6	4460.9
Caminha	42.0	0	805	188.8	120.2	241.1	215.7	128.5	257.8
Campo Maior	202.0	173	341	198.9	31.2	36.6	227.3	33.4	39.1
Cantanhede	75.0	0	137	201.8	69.6	81.5	230.6	74.4	87.1
Carrazeda de Ansiães	169.0	75	898	194.2	33.1	64.3	221.9	35.4	68.7
Carregal do Sal	115.0	150	375	198.4	53.4	66.1	226.7	57.1	70.7
Cartaxo	120.0	3	130	222.0	45.8	53.0	253.6	48.9	56.7
Cascais	24.0	0	475	204.5	219.0	349.0	233.7	234.1	373.0

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
Castanheira de Pêra	131.0	350	1205	210.0	58.4	101.9	239.9	62.5	108.9
Castelo Branco	191.0	121	1227	209.4	32.1	70.5	239.3	34.3	75.4
Castelo de Paiva	95.0	25	694	196.7	55.9	101.3	224.7	59.8	108.3
Castelo de Vide	186.0	125	825	205.9	32.8	57.6	235.3	35.0	61.6
Castro Daire	121.0	200	1375	197.0	53.3	115.9	225.2	57.0	123.9
Castro Marim	82.0	0	276	164.4	57.4	77.3	187.8	61.4	82.6
Castro Verde	123.0	125	288	191.6	47.8	56.2	219.0	51.1	60.1
Celorico da Beira	165.0	375	1256	197.5	46.0	80.4	225.7	49.1	86.0
Celorico de Basto	102.0	75	851	190.5	54.4	102.6	217.7	58.1	109.7
Chamusca	102.0	11	200	207.1	52.6	64.8	236.6	56.2	69.3
Chaves	151.0	300	1050	189.7	46.1	77.5	216.8	49.3	82.9
Cinfães	110.0	12	1381	196.8	47.6	127.8	224.9	50.8	136.6
Coimbra	115.0	9	500	210.4	46.9	75.3	240.4	50.1	80.5
Condeixa-a-Nova	110.0	12	466	211.1	49.3	76.8	241.2	52.7	82.1
Constância	110.0	22	224	205.8	49.2	61.3	235.2	52.6	65.6
Coruche	145.0	7	264	221.8	38.1	50.2	253.5	40.7	53.7
Corvo	3.4	0	718	107.2	1118.9	2123.2	122.5	1196.1	2269.7
Covilhã	199.0	375	1993	212.4	39.5	94.0	242.8	42.3	100.4
Crato	161.0	150	445	202.7	38.6	50.6	231.7	41.3	54.1
Cuba	124.0	150	309	191.5	48.7	56.8	218.8	52.0	60.8
Elvas	187.0	150	496	196.3	32.7	44.6	224.3	34.9	47.7
Entroncamento	102.0	25	87	207.0	53.4	57.5	236.5	57.1	61.4

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} [km]	h_{min} [m]	h_{max} [m]	Rumpf Rim-wave A_{800} [m]	Rumpf Rim-wave U_{min} [m]	Rumpf Rim-wave U_{max} [m]	Collins Rim-wave A_{800} [m]	Collins Rim-wave U_{min} [m]	Collins Rim-wave U_{max} [m]
Espinho	62.0	0	100	196.4	83.1	93.4	224.5	88.8	99.9
Esposende	36.0	0	281	188.7	140.2	189.5	215.7	149.9	202.6
Estarreja	64.0	0	130	196.5	80.5	93.6	224.6	86.0	100.0
Estremoz	200.0	205	653	211.9	33.6	48.6	242.2	35.9	51.9
Évora	153.0	150	441	203.4	40.7	53.1	232.4	43.5	56.8
Fafe	89.0	175	894	190.2	69.4	120.6	217.4	74.2	128.9
Faro	49.0	0	410	164.1	96.1	145.3	187.6	102.7	155.3
Felgueiras	82.0	145	575	189.4	72.9	106.0	216.5	77.9	113.3
Ferreira do Alentejo	105.0	24	277	188.6	49.5	64.7	215.5	52.9	69.2
Ferreira do Zêzere	115.0	125	451	206.8	53.1	71.8	236.3	56.8	76.8
Figueira da Foz	72.0	0	257	208.6	73.7	97.4	238.4	78.8	104.1
Figueira de Castelo Rodrigo	200.0	124	976	196.5	29.7	57.2	224.5	31.8	61.1
Figueiró dos Vinhos	120.0	125	1009	208.1	51.1	99.9	237.8	54.6	106.8
Fornos de Algodres	154.0	325	915	198.1	47.2	72.0	226.3	50.5	77.0
Freixo de Espada à Cinta	214.0	124	885	196.0	27.8	50.6	223.9	29.7	54.1
Fronteira	175.0	150	371	206.4	35.8	44.2	235.9	38.3	47.2
Funchal	3.1	0	1818	167.4	1533.5	5018.5	191.3	1639.3	5364.7
Fundão	198.0	275	1227	212.2	36.3	68.5	242.5	38.8	73.2
Gavião	143.0	50	312	205.5	39.1	51.2	234.8	41.8	54.7
Góis	144.0	150	1204	211.4	44.1	92.9	241.5	47.1	99.3
Golegã	100.0	14	95	206.7	53.8	59.1	236.2	57.5	63.2
Gondomar	70.0	5	470	195.3	73.8	116.5	223.2	78.9	124.5

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
Gouveia	168.0	250	1626	204.1	41.0	94.8	233.3	43.8	101.3
Grândola	38.0	0	325	183.7	131.1	184.3	209.9	140.1	197.0
Guarda	184.0	441	1287	200.4	43.9	73.7	229.0	46.9	78.8
Guimarães	79.0	83	613	190.4	70.8	113.4	217.6	75.7	121.2
Horta	15.0	0	1043	129.6	278.9	642.5	148.1	298.1	686.8
Idanha-a-Nova	215.0	125	828	210.4	28.7	50.4	240.4	30.6	53.9
Ílhavo	48.0	0	61	194.8	106.8	115.0	222.6	114.2	122.9
Lagoa (Açores)	12.0	0	947	169.4	398.6	870.4	193.6	426.1	930.4
Lagoa (Faro)	36.0	0	103	171.7	133.7	150.9	196.2	143.0	161.4
Lagos	50.0	0	255	178.9	98.3	129.6	204.4	105.1	138.6
Lajes das Flores	4.6	0	830	106.6	824.6	1680.1	121.8	881.5	1796.0
Lajes do Pico	4.5	0	2351	148.0	993.3	3912.5	169.1	1061.9	4182.4
Lamego	133.0	50	1122	196.6	41.2	93.1	224.7	44.0	99.5
Leiria	50.0	0	410	200.1	103.9	157.2	228.6	111.1	168.1
Lisboa	30.0	0	228	198.8	172.7	221.9	227.2	184.6	237.2
Loulé	44.0	0	589	165.6	107.5	186.6	189.3	114.9	199.5
Loures	30.0	0	409	200.4	173.4	262.0	229.0	185.4	280.1
Lourinhã	72.0	0	201	221.3	75.9	95.0	252.9	81.2	101.5
Lousã	130.0	75	1205	210.6	44.9	102.8	240.7	48.0	109.9
Lousada	85.0	175	578	192.8	73.2	103.4	220.4	78.2	110.5
Mação	108.0	47	643	196.3	50.5	86.0	224.4	54.0	91.9
Macedo de Cavaleiros	192.0	225	1263	191.0	33.9	68.2	218.3	36.2	72.9

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} [km]	h_{min} [m]	h_{max} [m]	Rumpf Rim-wave A_{800} [m]	Rumpf Rim-wave U_{min} [m]	Rumpf Rim-wave U_{max} [m]	Collins Rim-wave A_{800} [m]	Collins Rim-wave U_{min} [m]	Collins Rim-wave U_{max} [m]
Machico	5.3	0	1480	170.3	904.6	2578.2	194.6	967.0	2756.0
Madalena	9.6	0	2351	130.0	436.4	1719.0	148.6	466.5	1837.6
Mafra	65.0	0	431	217.4	83.4	128.3	248.5	89.1	137.1
Maia	59.0	35	255	193.6	90.5	114.3	221.3	96.7	122.2
Mangualde	132.0	225	766	197.1	50.1	76.5	225.2	53.5	81.8
Manteigas	171.0	518	1993	203.9	50.5	107.1	233.0	54.0	114.5
Marco de Canaveses	100.0	8	962	194.6	51.8	112.9	222.4	55.3	120.7
Marinha Grande	47.0	0	165	202.5	111.3	134.2	231.4	118.9	143.5
Marvão	164.0	200	1027	196.9	39.3	71.8	225.0	42.0	76.8
Matosinhos	52.0	0	134	193.6	98.3	114.8	221.2	105.1	122.7
Mealhada	108.0	25	568	208.5	50.7	84.0	238.3	54.2	89.8
Mêda	179.0	225	945	197.3	36.9	62.9	225.5	39.5	67.2
Melgaço	99.0	25	1336	189.7	52.7	136.5	216.8	56.4	145.9
Mértola	157.0	25	371	190.7	33.3	47.3	217.9	35.6	50.6
Mesão Frio	123.0	50	1038	194.8	44.3	95.8	222.7	47.4	102.4
Mira	74.0	0	64	205.2	71.1	76.8	234.4	76.0	82.1
Miranda do Corvo	118.0	50	940	209.0	47.8	97.9	238.9	51.1	104.7
Miranda do Douro	248.0	400	911	191.1	30.7	43.8	218.4	32.8	46.8
Mirandela	173.0	175	941	191.1	35.8	63.9	218.4	38.3	68.3
Mogadouro	211.0	150	997	191.7	28.6	54.2	219.0	30.6	57.9
Moimenta da Beira	149.0	375	1011	197.2	50.9	78.4	225.3	54.4	83.8
Moita	30.0	0	58	194.7	170.9	183.3	222.5	182.7	196.0

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

				Rumpf Rim-wave			Collins Rim-wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
Monção	75.0	9	1114	188.2	68.0	160.8	215.1	72.7	171.9
Monchique	75.0	25	902	185.2	68.8	141.8	211.6	73.5	151.6
Mondim de Basto	103.0	100	1307	189.6	55.3	129.4	216.6	59.1	138.3
Monforte	191.0	225	402	205.7	35.4	41.5	235.1	37.8	44.3
Montalegre	133.0	175	1527	191.3	46.6	111.2	218.6	49.8	118.8
Montemor-o-Novo	132.0	25	424	205.8	41.2	61.1	235.2	44.0	65.3
Montemor-o-Velho	95.0	2	127	211.3	56.4	65.2	241.5	60.3	69.6
Montijo	30.0	0	135	194.7	170.9	199.7	222.5	182.7	213.5
Mora	176.0	38	206	221.8	32.6	39.1	253.4	34.8	41.8
Mortágua	127.0	75	768	208.7	45.7	81.9	238.5	48.9	87.6
Moura	163.0	75	584	191.7	34.1	54.0	219.0	36.5	57.7
Mourão	148.0	100	286	186.7	38.2	46.1	213.4	40.8	49.2
Murça	146.0	175	1031	190.2	42.3	79.4	217.3	45.2	84.9
Murtosa	47.0	0	17	193.2	108.7	111.0	220.8	116.2	118.6
Nazaré	22.0	0	177	198.2	235.1	287.2	226.5	251.4	307.0
Nelas	129.0	150	484	198.7	47.7	64.4	227.0	51.0	68.9
Nisa	153.0	50	463	201.0	36.2	53.8	229.7	38.7	57.5
Nordeste	11.0	0	1103	178.2	445.9	1060.7	203.6	476.7	1133.9
Óbidos	27.0	0	222	201.5	193.2	246.8	230.3	206.5	263.8
Odemira	48.0	0	515	182.8	103.5	170.1	208.9	110.6	181.9
Odivelas	64.0	24	339	211.9	86.1	119.0	242.1	92.0	127.2
Oeiras	25.0	0	199	201.8	208.8	260.7	230.6	223.2	278.7

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
Oleiros	130.0	250	1085	201.4	52.6	94.5	230.1	56.3	101.0
Olhão	68.0	0	410	166.7	69.8	105.5	190.4	74.6	112.8
Oliveira de Azeméis	72.0	25	645	196.1	73.7	129.1	224.1	78.8	138.0
Oliveira de Frades	95.0	50	1062	196.0	57.5	126.0	223.9	61.5	134.7
Oliveira do Bairro	86.0	5	78	202.2	61.1	66.7	231.0	65.3	71.3
Oliveira do Hospital	159.0	150	1244	208.9	39.7	85.3	238.8	42.4	91.2
Ourém	91.0	95	678	207.2	65.0	107.4	236.8	69.5	114.8
Ourique	108.0	65	377	190.3	50.7	69.0	217.4	54.2	73.8
Ovar	57.0	0	225	195.3	90.1	115.4	223.2	96.3	123.4
Paços de Ferreira	77.0	175	570	192.8	80.8	113.5	220.3	86.3	121.3
Palmela	29.0	0	391	191.7	175.4	261.2	219.1	187.5	279.2
Pampilhosa da Serra	154.0	300	1418	210.3	47.6	95.9	240.3	50.9	102.5
Paredes	83.0	25	519	193.9	63.6	101.6	221.6	68.0	108.7
Paredes de Coura	70.0	125	883	190.1	83.7	152.3	217.3	89.5	162.8
Pedrógão Grande	133.0	150	779	208.8	47.4	78.8	238.6	50.7	84.2
Penacova	126.0	36	550	210.0	44.2	71.3	240.0	47.2	76.2
Penafiel	84.0	22	586	193.0	62.4	105.3	220.6	66.8	112.6
Penalva do Castelo	132.0	325	724	195.3	54.7	74.1	223.2	58.5	79.2
Penamacor	224.0	300	1076	211.4	32.8	55.9	241.6	35.1	59.8
Penedono	170.0	450	1000	197.9	47.5	68.4	226.1	50.8	73.1
Penela	115.0	150	873	209.5	54.9	96.7	239.4	58.7	103.4
Peniche	16.0	0	165	204.1	328.1	395.8	233.3	350.7	423.1

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

				Rumpf Rim-wave			Collins Rim-wave		
Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
Peso da Régua	130.0	50	1397	194.8	41.9	108.3	222.6	44.8	115.8
Pinhel	190.0	150	926	196.5	32.2	58.5	224.5	34.4	62.5
Pombal	65.0	0	560	200.1	80.0	135.9	228.7	85.5	145.3
Ponta Delgada	14.0	0	873	168.0	340.2	711.5	192.0	363.7	760.6
Ponta do Sol	4.3	0	1620	168.9	1110.5	3359.4	193.0	1187.2	3591.1
Ponte da Barca	80.0	25	1359	190.6	65.4	171.1	217.8	69.9	183.0
Ponte de Lima	66.0	3	835	190.8	77.2	157.2	218.0	82.5	168.0
Ponte de Sôr	138.0	46	285	205.3	40.3	51.7	234.5	43.1	55.3
Portalegre	188.0	250	1027	205.5	36.8	64.0	234.9	39.3	68.4
Portel	132.0	100	424	190.2	43.2	58.7	217.4	46.2	62.8
Portimão	46.0	0	325	175.6	105.9	148.9	200.7	113.2	159.1
Porto	56.0	0	157	193.1	91.2	109.1	220.7	97.5	116.6
Porto de Mós	44.0	50	615	198.4	125.0	208.1	226.7	133.6	222.4
Porto Moniz	4.0	0	1640	173.4	1209.5	3688.9	198.1	1292.9	3943.4
Porto Santo	6.3	0	517	178.6	779.5	1283.2	204.1	833.2	1371.7
Póvoa de Lanhoso	83.0	50	743	190.0	64.8	117.7	217.1	69.3	125.8
Póvoa de Varzim	33.0	0	202	188.6	152.9	191.5	215.6	163.5	204.8
Povoação	5.4	0	1103	174.3	898.3	2136.9	199.2	960.3	2284.3
Proença-a-Nova	128.0	114	954	200.9	46.5	89.2	229.6	49.7	95.4
Redondo	152.0	187	653	194.4	41.6	61.2	222.2	44.5	65.4
Reguengos de Monsaraz	133.0	100	363	187.4	42.5	55.0	214.1	45.5	58.8
Resende	116.0	50	1218	195.4	47.0	111.7	223.2	50.3	119.4

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$
Ribeira Brava	3.8	0	1725	168.5	1255.3	3962.1	192.6	1341.9	4235.4
Ribeira de Pena	121.0	153	1286	190.4	49.9	109.3	217.6	53.4	116.8
Ribeira Grande	8.2	0	877	170.2	584.7	1225.6	194.5	625.0	1310.1
Rio Maior	97.0	25	497	219.0	57.8	90.9	250.2	61.8	97.1
Sabrosa	143.0	75	1100	193.0	39.0	84.8	220.5	41.7	90.6
Sabugal	225.0	450	1223	209.3	36.9	59.7	239.1	39.5	63.9
Salvaterra de Magos	89.0	2	105	210.3	60.0	67.7	240.3	64.2	72.4
Santa Comba Dão	132.0	137	352	207.5	47.0	57.7	237.1	50.2	61.7
Santa Cruz	3.7	0	1415	168.8	1290.4	3572.9	192.9	1379.5	3819.4
Santa Cruz da Graciosa	8.7	0	402	137.2	494.7	743.3	156.8	528.8	794.6
Santa Cruz das Flores	3.4	0	914	106.9	1117.3	2393.7	122.1	1194.3	2558.8
Santa Maria da Feira	73.0	25	450	197.8	73.0	110.6	226.1	78.0	118.3
Santa Marta de Penaguião	130.0	75	1416	194.9	43.2	109.3	222.7	46.1	116.8
Santana	7.2	0	1862	172.5	670.2	2230.2	197.1	716.5	2384.0
Santarém	130.0	3	529	222.7	42.3	70.1	254.5	45.3	74.9
Santiago do Cacém	38.0	0	370	185.2	131.6	192.5	211.7	140.7	205.8
Santo Tirso	61.0	36	535	190.2	86.8	138.6	217.4	92.8	148.2
São Brás de Alportel	45.0	125	530	163.7	120.8	173.7	187.1	129.1	185.7
São João da Madeira	74.0	150	276	197.1	82.8	93.8	225.2	88.5	100.2
São João da Pesqueira	164.0	75	994	195.6	34.3	70.3	223.5	36.6	75.1
São Pedro do Sul	104.0	75	1119	196.0	54.1	118.7	224.0	57.8	126.8
São Roque do Pico	4.8	0	2351	166.8	988.7	3894.1	190.6	1056.9	4162.7

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave		
	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$	A_{800} $[m]$	U_{min} $[m]$	U_{max} $[m]$
São Vicente	4.7	0	1725	172.0	1025.2	3235.8	196.5	1095.9	3459.0
Sardoal	111.0	75	452	201.6	51.4	73.6	230.4	55.0	78.6
Sátão	132.0	375	859	195.9	57.2	80.8	223.9	61.2	86.4
Seia	163.0	175	1993	205.9	39.4	112.9	235.3	42.1	120.7
Seixal	30.0	0	81	197.5	172.1	189.5	225.6	184.0	202.6
Sernancelhe	152.0	475	964	195.3	53.8	74.5	223.2	57.6	79.6
Serpa	159.0	25	523	192.5	33.1	53.0	220.0	35.3	56.7
Sertã	132.0	125	1084	207.0	46.3	94.3	236.6	49.5	100.8
Sesimbra	9.9	0	380	190.3	512.0	755.1	217.4	547.3	807.2
Setúbal	29.0	0	501	191.5	175.3	285.1	218.8	187.4	304.8
Sever do Vouga	81.0	25	841	196.6	65.6	130.5	224.6	70.1	139.5
Silves	38.0	0	426	172.4	127.0	194.6	197.0	135.7	208.0
Sines	41.0	0	250	189.5	123.4	161.9	216.5	131.9	173.1
Sintra	37.0	0	528	208.3	143.3	237.9	238.0	153.2	254.3
Sobral de Monte Agraço	93.0	125	442	222.8	68.2	91.5	254.5	72.9	97.9
Soure	96.0	6	532	210.1	55.9	92.4	240.0	59.7	98.7
Sousel	175.0	150	454	206.7	35.8	47.3	236.1	38.3	50.6
Tábua	145.0	143	518	209.0	43.2	60.4	238.9	46.2	64.5
Tabuaço	152.0	75	985	196.2	37.0	75.6	224.2	39.6	80.8
Tarouca	137.0	325	1102	197.5	53.0	89.6	225.7	56.7	95.8
Tavira	52.0	0	541	160.9	89.6	150.3	183.9	95.8	160.6
Terras de Bouro	87.0	75	1525	190.9	63.8	169.6	218.2	68.2	181.3

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality	D_{shore} $[km]$	h_{min} $[m]$	h_{max} $[m]$	Rumpf Rim-wave A_{800} $[m]$	Rumpf Rim-wave U_{min} $[m]$	Rumpf Rim-wave U_{max} $[m]$	Collins Rim-wave A_{800} $[m]$	Collins Rim-wave U_{min} $[m]$	Collins Rim-wave U_{max} $[m]$
Tomar	89.0	32	350	201.5	60.9	84.2	230.2	65.2	90.1
Tondela	121.0	133	1075	202.2	50.4	101.2	231.1	53.8	108.2
Torre de Moncorvo	190.0	100	920	194.6	30.3	58.0	222.3	32.4	62.0
Torres Novas	88.0	13	678	204.5	60.7	110.3	233.6	64.9	117.9
Torres Vedras	71.0	0	394	218.4	76.5	114.1	249.5	81.8	122.0
Trancoso	166.0	425	986	196.4	47.5	69.2	224.4	50.8	74.0
Trofa	54.0	25	250	190.5	96.9	123.3	217.7	103.5	131.8
Vagos	51.0	0	68	196.2	100.9	109.5	224.2	107.9	117.0
Vale de Cambra	81.0	75	1046	196.8	69.6	146.8	224.8	74.4	157.0
Valença	65.0	0	784	189.5	77.8	154.1	216.5	83.2	164.7
Valongo	69.0	50	385	194.2	78.8	109.9	221.9	84.3	117.5
Valpaços	164.0	225	1148	190.7	39.6	75.3	217.9	42.4	80.5
Velas	3.0	0	1053	133.1	1413.0	3273.0	152.1	1510.5	3498.7
Vendas Novas	106.0	25	190	204.3	51.1	61.3	233.5	54.6	65.5
Viana do Alentejo	99.0	72	374	188.4	55.5	74.8	215.3	59.4	79.9
Viana do Castelo	35.0	0	823	188.3	144.1	292.3	215.2	154.0	312.5
Vidigueira	122.0	75	412	189.1	45.3	62.7	216.1	48.4	67.1
Vieira do Minho	95.0	75	1262	190.1	58.3	137.4	217.2	62.3	146.9
Vila da Praia da Vitória	22.0	0	808	151.5	205.6	413.2	173.1	219.8	441.7
Vila de Rei	128.0	125	594	206.9	47.7	72.0	236.4	51.0	76.9
Vila do Bispo	15.0	0	156	174.9	323.9	387.1	199.8	346.3	413.8
Vila do Conde	41.0	0	235	190.6	123.7	160.1	217.8	132.3	171.1

Table D.3.2: 5km Impactor's tsunami effects, for all studied municipalities (continuation)

Municipality				Rumpf Rim-wave			Collins Rim-wave		
	D_{shore} [km]	h_{min} [m]	h_{max} [m]	A_{800} [m]	U_{min} [m]	U_{max} [m]	A_{800} [m]	U_{min} [m]	U_{max} [m]
Vila do Porto	5.0	0	587	168.6	954.2	1654.3	192.6	1020.0	1768.4
Vila Flor	177.0	123	837	192.5	33.2	58.9	220.0	35.5	63.0
Vila Franca de Xira	30.0	0	378	196.5	171.7	252.8	224.5	183.5	270.2
Vila Franca do Campo	7.7	0	947	170.8	623.7	1361.9	195.2	666.7	1455.9
Vila Nova da Barquinha	103.0	19	201	206.3	52.5	64.1	235.7	56.1	68.5
Vila Nova de Cerveira	54.0	0	638	189.4	93.6	168.3	216.4	100.1	179.9
Vila Nova de Famalicão	60.0	25	462	190.5	87.2	133.3	217.7	93.2	142.5
Vila Nova de Foz Côa	189.0	82	814	198.3	30.2	55.2	226.6	32.3	59.0
Vila Nova de Gaia	60.0	0	262	194.5	85.4	113.4	222.3	91.3	121.2
Vila Nova de Paiva	133.0	550	1036	195.7	65.2	88.7	223.6	69.7	94.8
Vila Nova de Poiares	125.0	42	458	209.1	44.7	66.8	239.0	47.8	71.5
Vila Pouca de Aguiar	133.0	225	1205	190.3	48.8	95.5	217.5	52.2	102.1
Vila Real	127.0	125	1350	192.1	46.4	107.8	219.6	49.6	115.2
Vila Real de Santo António	81.0	0	225	163.5	58.0	74.3	186.8	62.0	79.4
Vila Velha de Ródão	139.0	50	570	198.3	39.6	63.7	226.6	42.3	68.1
Vila Verde	72.0	21	789	190.2	72.2	139.8	217.3	77.2	149.4
Vila Viçosa	163.0	165	475	195.1	38.0	50.2	223.0	40.6	53.6
Vimioso	228.0	250	955	190.9	29.2	48.8	218.1	31.2	52.2
Vinhais	198.0	275	1273	191.8	34.5	66.6	219.1	36.9	71.2
Viseu	121.0	200	899	197.3	53.3	90.6	225.5	57.0	96.9
Vizela	74.0	125	478	188.7	78.9	109.0	215.6	84.3	116.5
Vouzela	103.0	125	1043	196.8	57.9	115.3	224.9	61.9	123.3

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_p
Abrantes	4.524	0	6.069	2	4.202	0	4.939	1	4.734	0	10.656	3
Águeda	4.741	0	6.247	2	4.404	0	5.125	2	5.082	0	11.127	5
Aguiar da Beira	3.945	0	5.624	0	3.662	0	4.482	0	3.847	0	9.506	0
Alandroal	3.777	0	5.502	0	3.506	0	4.358	0	3.602	0	9.200	0
Albergaria-a-Velha	4.760	0	6.263	1	4.421	0	5.141	1	5.113	0	11.169	2
Albufeira	3.951	0	5.629	2	3.668	0	4.487	1	3.857	0	9.519	3
Alcácer do Sal	4.618	0	6.145	0	4.289	0	5.019	0	4.884	0	10.857	1
Alcanena	4.996	0	6.464	0	4.642	0	5.353	0	5.502	0	11.711	1
Alcobaça	12.741	0	6.789	3	11.872	0	5.699	3	22.702	0	12.604	6
Alcochete	11.036	0	6.639	1	10.278	0	5.539	1	18.264	0	12.189	2
Alcoutim	3.553	0	5.345	0	3.297	0	4.200	0	3.284	0	8.808	0
Alenquer	12.355	0	6.756	2	11.511	0	5.664	2	21.668	0	12.512	5
Alfândega da Fé	3.491	0	5.303	0	3.240	0	4.158	0	3.198	0	8.705	0
Alijó	3.833	0	5.543	0	3.558	0	4.399	0	3.683	0	9.301	0
Aljezur	4.488	0	6.040	0	4.168	0	4.909	0	4.677	0	10.579	0
Aljustrel	4.162	0	5.786	0	3.864	0	4.647	0	4.172	0	9.919	0
Almada	13.237	0	6.831	11	12.335	2	5.744	9	24.053	0	12.721	21
Almeida	3.521	0	5.324	0	3.268	0	4.178	0	3.240	0	8.755	0
Almeirim	4.908	0	6.388	1	4.560	0	5.273	1	5.356	0	11.506	2
Almodôvar	3.963	0	5.638	0	3.679	0	4.496	0	3.875	0	9.541	0
Alpiarça	4.879	0	6.363	0	4.532	0	5.247	0	5.308	0	11.438	0
Alter do Chão	4.034	0	5.690	0	3.745	0	4.549	0	3.980	0	9.674	0

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Alvaiázere	4.717	0	6.227	0	4.381	0	5.104	0	5.043	0	11.073	0
Alvito	4.129	0	5.761	0	3.833	0	4.621	0	4.122	0	9.855	0
Amadora	14.709	0	6.950	12	13.711	2	5.873	10	28.214	0	13.057	23
Amarante	4.293	0	5.887	3	3.987	0	4.751	2	4.374	0	10.180	5
Amares	4.429	0	5.993	1	4.113	0	4.861	0	4.585	0	10.457	1
Anadia	4.746	0	6.251	1	4.409	0	5.129	1	5.091	0	11.138	3
Angra do Heroísmo	3.315	0	5.184	1	3.076	0	4.039	1	2.957	0	8.414	2
Ansião	4.774	0	6.274	0	4.434	0	5.154	0	5.136	0	11.200	1
Arcos de Valdevez	4.412	0	5.980	1	4.098	0	4.847	1	4.558	0	10.422	2
Arganil	4.406	0	5.975	0	4.091	0	4.842	0	4.548	0	10.409	1
Armamar	4.016	0	5.676	0	3.728	0	4.535	0	3.953	0	9.639	0
Arouca	4.499	0	6.050	1	4.179	0	4.919	1	4.695	0	10.604	2
Arraiolos	4.227	0	5.836	0	3.925	0	4.698	0	4.272	0	10.048	0
Arronches	3.751	0	5.484	0	3.482	0	4.340	0	3.565	0	9.154	0
Arruda dos Vinhos	13.082	0	6.818	1	12.191	0	5.730	0	23.628	0	12.684	1
Aveiro	4.936	0	6.412	4	4.585	0	5.298	4	5.402	0	11.569	9
Avis	4.204	0	5.818	0	3.904	0	4.680	0	4.237	0	10.003	0
Azambuja	10.717	0	6.609	1	9.980	0	5.508	1	17.470	0	12.109	2
Baião	4.276	0	5.874	1	3.971	0	4.737	0	4.347	0	10.145	1
Barcelos	4.691	0	6.206	7	4.358	0	5.082	5	5.002	0	11.017	12
Barrancos	3.401	0	5.242	0	3.155	0	4.096	0	3.073	0	8.554	0
Barreiro	12.088	0	6.733	5	11.262	0	5.639	4	20.964	0	12.448	9

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Batalha	10.960	0	6.632	1	10.207	0	5.531	0	18.073	0	12.170	1
Beja	3.967	0	5.640	1	3.682	0	4.498	1	3.880	0	9.547	3
Belmonte	3.837	0	5.546	0	3.562	0	4.402	0	3.690	0	9.309	0
Benavente	5.075	0	6.533	1	4.715	0	5.426	1	5.634	0	11.898	3
Bombarral	14.897	0	6.965	0	13.887	0	5.889	0	28.764	0	13.099	1
Borba	3.829	0	5.540	0	3.555	0	4.396	0	3.678	0	9.295	0
Boticas	3.887	0	5.582	0	3.608	0	4.439	0	3.763	0	9.400	0
Braga	4.512	0	6.059	11	4.190	0	4.929	8	4.715	0	10.630	19
Bragança	3.306	0	5.179	1	3.068	0	4.033	1	2.945	0	8.400	2
Cabeceiras de Basto	4.165	0	5.789	0	3.867	0	4.650	0	4.177	0	9.926	1
Cadaval	14.033	0	6.896	0	13.080	0	5.814	0	26.277	0	12.904	1
Caldas da Rainha	14.841	0	6.961	3	13.835	0	5.884	3	28.600	0	13.086	6
Calheta (Açores)	2.894	0	4.914	0	2.684	0	3.772	0	2.408	0	7.765	0
Calheta (Madeira)	4.343	0	5.925	0	4.033	0	4.790	0	4.450	0	10.280	1
Câmara de Lobos	4.283	0	5.879	1	3.977	0	4.743	1	4.358	0	10.159	3
Caminha	4.780	0	6.280	0	4.440	0	5.159	0	5.146	0	11.214	1
Campo Maior	3.590	0	5.371	0	3.332	0	4.226	0	3.336	0	8.873	0
Cantanhede	4.919	0	6.397	2	4.569	0	5.283	1	5.374	0	11.530	4
Carrazeda de Ansiães	3.724	0	5.465	0	3.457	0	4.320	0	3.526	0	9.106	0
Carregal do Sal	4.343	0	5.926	0	4.033	0	4.791	0	4.451	0	10.281	0
Cartaxo	5.087	0	6.543	1	4.726	0	5.437	1	5.654	0	11.927	2
Cascais	17.473	0	7.162	15	16.297	3	6.102	12	36.620	0	13.657	29

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Castanheira de Pêra	4.554	0	6.094	0	4.230	0	4.965	0	4.782	0	10.720	0
Castelo Branco	3.947	0	5.626	2	3.664	0	4.484	2	3.851	0	9.511	4
Castelo de Paiva	4.492	0	6.044	0	4.172	0	4.913	0	4.684	0	10.589	1
Castelo de Vide	3.899	0	5.591	0	3.619	0	4.448	0	3.780	0	9.422	0
Castro Daire	4.237	0	5.844	0	3.935	0	4.706	0	4.288	0	10.068	1
Castro Marim	3.465	0	5.285	0	3.215	0	4.139	0	3.161	0	8.660	0
Castro Verde	4.043	0	5.697	0	3.753	0	4.556	0	3.993	0	9.691	0
Celorico da Beira	3.850	0	5.555	0	3.574	0	4.412	0	3.709	0	9.332	0
Celorico de Basto	4.203	0	5.817	1	3.902	0	4.679	0	4.235	0	10.000	1
Chamusca	4.788	0	6.286	0	4.447	0	5.166	0	5.158	0	11.231	1
Chaves	3.743	0	5.479	2	3.474	0	4.334	1	3.554	0	9.140	3
Cinfães	4.339	0	5.923	1	4.029	0	4.788	0	4.444	0	10.273	1
Coimbra	4.750	0	6.255	8	4.412	0	5.133	6	5.097	0	11.147	14
Condeixa-a-Nova	4.834	0	6.325	1	4.491	0	5.207	0	5.234	0	11.336	1
Constância	4.651	0	6.173	0	4.320	0	5.047	0	4.937	0	10.929	0
Coruche	4.771	0	6.272	1	4.432	0	5.151	0	5.131	0	11.193	1
Corvo	1.904	0	4.342	0	1.763	0	3.220	0	1.277	0	6.449	0
Covilhã	3.954	0	5.631	2	3.671	0	4.489	2	3.861	0	9.523	4
Crato	4.033	0	5.690	0	3.745	0	4.548	0	3.979	0	9.673	0
Cuba	4.028	0	5.685	0	3.739	0	4.544	0	3.971	0	9.662	0
Elvas	3.638	0	5.405	1	3.377	0	4.259	0	3.404	0	8.955	1
Entroncamento	4.784	0	6.283	1	4.444	0	5.162	1	5.152	0	11.223	2

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Espinho	4.861	0	6.348	1	4.516	0	5.231	1	5.279	0	11.398	3
Esposende	4.852	0	6.340	2	4.507	0	5.222	1	5.263	0	11.376	3
Estarreja	4.842	0	6.331	1	4.498	0	5.213	1	5.247	0	11.353	2
Estremoz	3.932	0	5.615	0	3.650	0	4.472	0	3.828	0	9.482	1
Évora	4.126	0	5.759	3	3.831	0	4.620	2	4.119	0	9.850	5
Fafe	4.323	0	5.910	2	4.014	0	4.774	2	4.419	0	10.239	4
Faro	3.707	0	5.453	3	3.440	0	4.308	2	3.502	0	9.075	5
Felgueiras	4.365	0	5.943	3	4.053	0	4.809	2	4.485	0	10.325	5
Ferreira do Alentejo	4.107	0	5.745	0	3.813	0	4.605	0	4.090	0	9.814	0
Ferreira do Zêzere	4.626	0	6.152	0	4.297	0	5.026	0	4.898	0	10.876	0
Figueira da Foz	11.379	0	6.670	3	10.598	0	5.572	3	19.129	0	12.274	7
Figueira de Castelo Rodrigo	3.543	0	5.339	0	3.288	0	4.193	0	3.271	0	8.793	0
Figueiró dos Vinhos	4.616	0	6.144	0	4.287	0	5.017	0	4.880	0	10.852	0
Fornos de Algodres	3.960	0	5.636	0	3.677	0	4.493	0	3.871	0	9.535	0
Freixo de Espada à Cinta	3.429	0	5.261	0	3.182	0	4.115	0	3.112	0	8.601	0
Fronteira	4.010	0	5.672	0	3.722	0	4.530	0	3.944	0	9.628	0
Funchal	4.252	0	5.855	6	3.948	0	4.718	4	4.310	0	10.097	10
Fundão	3.956	0	5.633	1	3.673	0	4.490	1	3.864	0	9.527	2
Gavião	4.286	0	5.882	0	3.980	0	4.745	0	4.363	0	10.166	0
Góis	4.458	0	6.017	0	4.140	0	4.885	0	4.631	0	10.518	0
Golegã	4.798	0	6.294	0	4.457	0	5.175	0	5.175	0	11.254	0
Gondomar	4.722	0	6.231	10	4.386	0	5.108	8	5.052	0	11.085	18

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Gouveia	4.009	0	5.672	0	3.722	0	4.530	0	3.944	0	9.627	1
Grândola	4.607	0	6.137	0	4.279	0	5.010	0	4.867	0	10.834	1
Guarda	3.770	0	5.497	2	3.499	0	4.353	1	3.592	0	9.187	3
Guimarães	4.433	0	5.997	9	4.117	0	4.864	7	4.591	0	10.465	15
Horta	2.625	0	4.750	0	2.434	0	3.612	0	2.077	0	7.379	1
Idanha-a-Nova	3.768	0	5.496	0	3.497	0	4.352	0	3.589	0	9.183	0
Ílhavo	4.965	0	6.437	2	4.613	0	5.325	2	5.451	0	11.639	4
Lagoa (Açores)	4.256	0	5.858	0	3.952	0	4.721	0	4.317	0	10.106	1
Lagoa (Faro)	4.120	0	5.755	1	3.825	0	4.615	1	4.109	0	9.839	2
Lagos	4.280	0	5.877	1	3.975	0	4.741	1	4.354	0	10.154	3
Lajes das Flores	1.880	0	4.329	0	1.741	0	3.208	0	1.253	0	6.421	0
Lajes do Pico	3.396	0	5.239	0	3.151	0	4.093	0	3.067	0	8.546	0
Lamego	4.108	0	5.745	1	3.814	0	4.605	1	4.091	0	9.815	2
Leiria	10.779	0	6.615	8	10.038	1	5.514	6	17.624	0	12.124	15
Lisboa	13.047	0	6.815	34	12.158	6	5.727	29	23.532	1	12.676	64
Loulé	3.806	0	5.524	3	3.533	0	4.380	3	3.645	0	9.253	6
Loures	13.894	0	6.885	14	12.949	2	5.802	12	25.882	0	12.872	27
Lourinhã	17.463	0	7.161	1	16.288	0	6.101	1	36.588	0	13.655	3
Lousã	4.586	0	6.120	1	4.260	0	4.992	0	4.834	0	10.789	1
Lousada	4.460	0	6.018	2	4.142	0	4.886	2	4.633	0	10.521	4
Mação	4.345	0	5.927	0	4.035	0	4.792	0	4.453	0	10.284	0
Macedo de Cavaleiros	3.464	0	5.284	0	3.214	0	4.139	0	3.160	0	8.658	1

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Machico	4.361	0	5.940	1	4.050	0	4.806	0	4.479	0	10.318	2
Madalena	2.665	0	4.774	0	2.471	0	3.635	0	2.125	0	7.436	0
Mafra	16.764	0	7.109	5	15.634	1	6.045	5	34.394	0	13.507	11
Maia	4.784	0	6.283	8	4.444	0	5.162	7	5.152	0	11.223	15
Mangualde	4.132	0	5.764	1	3.837	0	4.624	0	4.128	0	9.862	1
Manteigas	3.975	0	5.647	0	3.691	0	4.505	0	3.893	0	9.564	0
Marco de Canaveses	4.367	0	5.945	3	4.055	0	4.810	2	4.488	0	10.330	5
Marinha Grande	12.287	0	6.750	2	11.448	0	5.657	2	21.489	0	12.496	4
Marvão	3.841	0	5.549	0	3.565	0	4.405	0	3.695	0	9.315	0
Matosinhos	4.866	0	6.352	11	4.521	0	5.236	9	5.287	0	11.410	19
Mealhada	4.768	0	6.270	1	4.429	0	5.149	1	5.126	0	11.187	2
Mêda	3.729	0	5.469	0	3.461	0	4.324	0	3.534	0	9.115	0
Melgaço	4.205	0	5.819	0	3.904	0	4.681	0	4.238	0	10.004	0
Mértola	3.721	0	5.463	0	3.454	0	4.319	0	3.523	0	9.101	0
Mesão Frio	4.146	0	5.774	0	3.850	0	4.635	0	4.149	0	9.889	0
Mira	5.064	0	6.523	0	4.705	0	5.416	0	5.615	0	11.871	1
Miranda do Corvo	4.669	0	6.187	0	4.337	0	5.063	0	4.966	0	10.968	1
Miranda do Douro	3.097	0	5.042	0	2.873	0	3.898	0	2.667	0	8.070	0
Mirandela	3.609	0	5.384	1	3.349	0	4.239	0	3.362	0	8.905	1
Mogadouro	3.347	0	5.205	0	3.105	0	4.060	0	3.000	0	8.465	0
Moimenta da Beira	3.979	0	5.649	0	3.694	0	4.507	0	3.898	0	9.569	0
Moita	11.078	0	6.643	4	10.317	0	5.543	3	18.368	0	12.200	7

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Monção	4.392	0	5.964	1	4.078	0	4.830	0	4.526	0	10.380	1
Monchique	4.276	0	5.874	0	3.971	0	4.737	0	4.348	0	10.146	0
Mondim de Basto	4.161	0	5.785	0	3.863	0	4.646	0	4.171	0	9.918	0
Monforte	3.851	0	5.556	0	3.575	0	4.412	0	3.710	0	9.334	0
Montalegre	3.943	0	5.623	0	3.660	0	4.480	0	3.844	0	9.502	0
Montemor-o-Novo	4.410	0	5.979	0	4.096	0	4.846	0	4.556	0	10.419	1
Montemor-o-Velho	5.030	0	6.494	1	4.673	0	5.384	1	5.559	0	11.792	2
Montijo	11.051	0	6.640	3	10.292	0	5.540	3	18.301	0	12.193	6
Mora	4.423	0	5.989	0	4.108	0	4.856	0	4.576	0	10.445	0
Mortágua	4.557	0	6.096	0	4.232	0	4.967	0	4.786	0	10.725	0
Moura	3.701	0	5.449	0	3.435	0	4.304	0	3.494	0	9.066	1
Mourão	3.679	0	5.433	0	3.414	0	4.288	0	3.462	0	9.026	0
Murça	3.797	0	5.517	0	3.525	0	4.373	0	3.632	0	9.237	0
Murtosa	4.912	0	6.391	0	4.563	0	5.277	0	5.363	0	11.515	1
Nazaré	14.040	0	6.897	0	13.086	0	5.815	0	26.296	0	12.906	1
Nelas	4.212	0	5.824	0	3.911	0	4.686	0	4.249	0	10.018	1
Nisa	4.055	0	5.706	0	3.765	0	4.565	0	4.012	0	9.714	0
Nordeste	4.667	0	6.186	0	4.335	0	5.061	0	4.964	0	10.965	0
Óbidos	15.053	0	6.978	0	14.033	0	5.902	0	29.220	0	13.134	1
Odemira	4.462	0	6.020	1	4.144	0	4.888	1	4.637	0	10.526	2
Odivelas	14.060	0	6.898	11	13.104	2	5.817	9	26.352	0	12.910	20
Oeiras	15.548	0	7.016	12	14.496	2	5.944	10	30.688	0	13.243	23

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Oleiros	4.288	0	5.883	0	3.982	0	4.747	0	4.366	0	10.170	0
Olhão	3.651	0	5.414	2	3.388	0	4.268	1	3.422	0	8.978	4
Oliveira de Azeméis	4.731	0	6.239	4	4.394	0	5.116	3	5.066	0	11.104	7
Oliveira de Frades	4.467	0	6.024	0	4.149	0	4.892	0	4.645	0	10.536	1
Oliveira do Bairro	4.798	0	6.295	1	4.457	0	5.175	1	5.175	0	11.254	2
Oliveira do Hospital	4.231	0	5.839	1	3.929	0	4.702	0	4.279	0	10.057	1
Ourém	4.928	0	6.405	2	4.578	0	5.291	2	5.388	0	11.551	5
Ourique	4.137	0	5.767	0	3.841	0	4.628	0	4.135	0	9.872	0
Ovar	4.877	0	6.361	3	4.530	0	5.245	2	5.305	0	11.434	6
Paços de Ferreira	4.545	0	6.087	3	4.222	0	4.957	2	4.768	0	10.701	6
Palmela	5.074	0	6.531	4	4.714	0	5.425	3	5.632	0	11.895	7
Pampilhosa da Serra	4.321	0	5.909	0	4.012	0	4.773	0	4.416	0	10.236	0
Paredes	4.522	0	6.068	5	4.200	0	4.938	4	4.731	0	10.652	9
Paredes de Coura	4.519	0	6.065	0	4.197	0	4.935	0	4.726	0	10.644	0
Pedrógão Grande	4.494	0	6.046	0	4.174	0	4.915	0	4.688	0	10.594	0
Penacova	4.613	0	6.141	0	4.284	0	5.014	0	4.876	0	10.846	1
Penafiel	4.478	0	6.033	4	4.159	0	4.901	3	4.662	0	10.559	7
Penalva do Castelo	4.076	0	5.722	0	3.784	0	4.581	0	4.043	0	9.754	0
Penamacor	3.718	0	5.461	0	3.451	0	4.316	0	3.518	0	9.095	0
Penedono	3.817	0	5.531	0	3.543	0	4.387	0	3.660	0	9.272	0
Penela	4.720	0	6.230	0	4.385	0	5.107	0	5.049	0	11.081	0
Peniche	18.953	0	7.269	1	17.681	0	6.219	1	41.414	0	13.965	3

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Peso da Régua	4.079	0	5.724	0	3.787	0	4.583	0	4.047	0	9.759	1
Pinhel	3.619	0	5.391	0	3.359	0	4.246	0	3.377	0	8.923	0
Pombal	4.975	0	6.446	3	4.622	0	5.334	2	5.467	0	11.661	6
Ponta Delgada	4.175	0	5.796	3	3.877	0	4.657	3	4.193	0	9.945	6
Ponta do Sol	4.309	0	5.899	0	4.002	0	4.764	0	4.398	0	10.212	0
Ponte da Barca	4.430	0	5.995	0	4.114	0	4.862	0	4.587	0	10.460	1
Ponte de Lima	4.588	0	6.121	2	4.262	0	4.994	2	4.837	0	10.793	4
Ponte de Sôr	4.330	0	5.916	0	4.021	0	4.781	0	4.431	0	10.255	1
Portalegre	3.871	0	5.571	1	3.594	0	4.427	0	3.740	0	9.371	2
Portel	3.918	0	5.604	0	3.637	0	4.462	0	3.808	0	9.456	0
Portimão	4.188	0	5.806	3	3.889	0	4.668	2	4.212	0	9.971	5
Porto	4.797	0	6.294	13	4.456	0	5.174	11	5.174	0	11.253	24
Porto de Mós	10.852	0	6.622	1	10.106	0	5.521	1	17.804	0	12.143	2
Porto Moniz	4.519	0	6.065	0	4.197	0	4.935	0	4.727	0	10.646	0
Porto Santo	4.741	0	6.247	0	4.404	0	5.125	0	5.083	0	11.127	0
Póvoa de Lanhoso	4.374	0	5.950	1	4.062	0	4.816	1	4.499	0	10.344	2
Póvoa de Varzim	4.883	0	6.367	3	4.536	0	5.250	3	5.315	0	11.448	7
Povoação	4.547	0	6.088	0	4.223	0	4.959	0	4.772	0	10.706	0
Proença-a-Nova	4.294	0	5.887	0	3.987	0	4.751	0	4.374	0	10.181	0
Redondo	3.871	0	5.570	0	3.593	0	4.427	0	3.739	0	9.370	0
Reguengos de Monsaraz	3.821	0	5.534	0	3.547	0	4.390	0	3.666	0	9.279	0
Resende	4.231	0	5.839	0	3.928	0	4.701	0	4.277	0	10.055	1

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Ribeira Brava	4.298	0	5.890	0	3.991	0	4.754	0	4.380	0	10.189	1
Ribeira de Pena	4.022	0	5.681	0	3.734	0	4.539	0	3.961	0	9.650	0
Ribeira Grande	4.330	0	5.916	1	4.021	0	4.781	1	4.431	0	10.255	3
Rio Maior	11.994	0	6.724	1	11.173	0	5.630	1	20.717	0	12.425	2
Sabrosa	3.905	0	5.595	0	3.626	0	4.452	0	3.790	0	9.434	0
Sabugal	3.660	0	5.420	0	3.397	0	4.275	0	3.435	0	8.994	0
Salvaterra de Magos	5.069	0	6.527	1	4.710	0	5.420	1	5.624	0	11.884	2
Santa Comba Dão	4.464	0	6.021	0	4.146	0	4.890	0	4.640	0	10.530	1
Santa Cruz	4.313	0	5.902	2	4.005	0	4.767	2	4.404	0	10.220	4
Santa Cruz da Graciosa	2.940	0	4.942	0	2.727	0	3.800	0	2.466	0	7.833	0
Santa Cruz das Flores	1.893	0	4.336	0	1.754	0	3.215	0	1.266	0	6.437	0
Santa Maria da Feira	4.786	0	6.284	8	4.446	0	5.164	7	5.155	0	11.227	15
Santa Marta de Penaguião	4.081	0	5.725	0	3.789	0	4.585	0	4.050	0	9.763	0
Santana	4.444	0	6.005	0	4.127	0	4.873	0	4.608	0	10.488	0
Santarém	4.984	0	6.453	3	4.630	0	5.342	3	5.481	0	11.682	6
Santiago do Cacém	4.675	0	6.192	1	4.342	0	5.067	1	4.975	0	10.980	3
Santo Tirso	4.621	0	6.148	4	4.292	0	5.021	3	4.889	0	10.863	7
São Brás de Alportel	3.723	0	5.464	0	3.455	0	4.319	0	3.525	0	9.104	0
São João da Madeira	4.743	0	6.249	1	4.406	0	5.127	1	5.086	0	11.132	2
São João da Pesqueira	3.804	0	5.522	0	3.531	0	4.378	0	3.641	0	9.248	0
São Pedro do Sul	4.374	0	5.950	0	4.062	0	4.816	0	4.499	0	10.344	1
São Roque do Pico	4.208	0	5.822	0	3.908	0	4.684	0	4.243	0	10.011	0

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

Municipality	best				expected				worst			
	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
São Vicente	4.446	0	6.007	0	4.129	0	4.875	0	4.612	0	10.493	0
Sardoal	4.494	0	6.045	0	4.173	0	4.914	0	4.686	0	10.592	0
Sátão	4.096	0	5.737	0	3.803	0	4.596	0	4.073	0	9.793	1
Seia	4.105	0	5.743	1	3.812	0	4.603	1	4.087	0	9.810	2
Seixal	12.377	0	6.758	11	11.531	1	5.666	9	21.727	0	12.517	20
Sernancelhe	3.898	0	5.590	0	3.619	0	4.447	0	3.779	0	9.421	0
Serpa	3.758	0	5.489	0	3.488	0	4.345	0	3.575	0	9.166	1
Sertã	4.450	0	6.010	0	4.132	0	4.878	0	4.617	0	10.500	1
Sesimbra	11.695	0	6.698	3	10.894	0	5.602	2	19.939	0	12.352	6
Setúbal	5.061	0	6.521	7	4.702	0	5.413	6	5.611	0	11.866	13
Sever do Vouga	4.644	0	6.167	0	4.314	0	5.041	0	4.926	0	10.914	1
Silves	4.130	0	5.762	2	3.835	0	4.623	1	4.125	0	9.859	3
Sines	4.824	0	6.317	0	4.481	0	5.198	0	5.218	0	11.313	1
Sintra	17.127	0	7.136	27	15.973	6	6.074	23	35.526	1	13.584	52
Sobral de Monte Agraço	14.205	0	6.910	0	13.240	0	5.829	0	26.765	0	12.943	1
Soure	4.970	0	6.441	1	4.617	0	5.329	0	5.459	0	11.650	2
Sousel	4.016	0	5.677	0	3.728	0	4.535	0	3.953	0	9.640	0
Tábua	4.376	0	5.952	0	4.064	0	4.817	0	4.502	0	10.347	1
Tabuaço	3.923	0	5.609	0	3.642	0	4.466	0	3.816	0	9.467	0
Tarouca	4.099	0	5.738	0	3.805	0	4.598	0	4.077	0	9.797	0
Tavira	3.562	0	5.351	1	3.305	0	4.206	1	3.296	0	8.824	2
Terras de Bouro	4.368	0	5.945	0	4.056	0	4.811	0	4.490	0	10.332	0

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Tomar	4.737	0	6.243	2	4.400	0	5.121	1	5.075	0	11.117	4
Tondela	4.409	0	5.977	1	4.094	0	4.844	1	4.553	0	10.415	2
Torre de Moncorvo	3.570	0	5.357	0	3.313	0	4.212	0	3.308	0	8.838	0
Torres Novas	4.860	0	6.347	2	4.515	0	5.230	1	5.277	0	11.396	3
Torres Vedras	16.081	0	7.058	5	14.994	1	5.989	4	32.294	0	13.359	10
Trancoso	3.809	0	5.526	0	3.536	0	4.382	0	3.649	0	9.257	0
Trofa	4.714	0	6.225	2	4.379	0	5.102	1	5.039	0	11.068	4
Vagos	4.987	0	6.456	1	4.633	0	5.345	1	5.487	0	11.690	2
Vale de Cambra	4.651	0	6.172	1	4.320	0	5.047	1	4.937	0	10.929	2
Valença	4.547	0	6.088	0	4.223	0	4.959	0	4.771	0	10.705	1
Valongo	4.689	0	6.204	5	4.355	0	5.080	4	4.998	0	11.012	10
Valpaços	3.667	0	5.425	0	3.403	0	4.280	0	3.444	0	9.005	1
Velas	2.814	0	4.864	0	2.609	0	3.723	0	2.307	0	7.647	0
Vendas Novas	4.643	0	6.166	0	4.313	0	5.040	0	4.925	0	10.912	1
Viana do Alentejo	4.158	0	5.784	0	3.861	0	4.644	0	4.167	0	9.913	0
Viana do Castelo	4.846	0	6.335	5	4.501	0	5.217	4	5.253	0	11.362	9
Vidigueira	3.969	0	5.642	0	3.684	0	4.500	0	3.883	0	9.551	0
Vieira do Minho	4.256	0	5.859	0	3.952	0	4.722	0	4.317	0	10.106	1
Vila da Praia da Vitória	3.416	0	5.252	1	3.169	0	4.106	0	3.094	0	8.578	1
Vila de Rei	4.488	0	6.040	0	4.168	0	4.909	0	4.677	0	10.579	0
Vila do Bispo	4.470	0	6.026	0	4.152	0	4.895	0	4.650	0	10.543	0
Vila do Conde	4.872	0	6.357	5	4.526	0	5.240	4	5.296	0	11.422	9

Table D.3.3: 5km Impactor's seismic shaking and overpressure vulnerabilities and casualties, for all studied municipalities (continuation)

	best				expected				worst			
Municipality	V_{seis} $[10^{-7}]$	C_{seis}	V_p $[10^{-5}]$	C_{seis}	V_{seis} $[10^{-6}]$	C_{seis}	V_p $[10^{-5}]$	C_p	V_{seis} $[10^{-7}]$	C_p	V_p $[10^{-5}]$	C_p
Vila do Porto	4.287	0	5.883	0	3.981	0	4.746	0	4.365	0	10.168	0
Vila Flor	3.615	0	5.388	0	3.355	0	4.243	0	3.371	0	8.915	0
Vila Franca de Xira	11.883	0	6.715	9	11.070	1	5.620	7	20.429	0	12.398	17
Vila Franca do Campo	4.362	0	5.940	0	4.050	0	4.806	0	4.480	0	10.319	1
Vila Nova da Barquinha	4.749	0	6.253	0	4.411	0	5.131	0	5.095	0	11.144	0
Vila Nova de Cerveira	4.667	0	6.185	0	4.335	0	5.061	0	4.962	0	10.963	0
Vila Nova de Famalicão	4.645	0	6.167	8	4.314	0	5.042	6	4.927	0	10.915	14
Vila Nova de Foz Côa	3.675	0	5.430	0	3.410	0	4.285	0	3.456	0	9.019	0
Vila Nova de Gaia	4.808	0	6.303	18	4.466	1	5.183	15	5.191	0	11.276	33
Vila Nova de Paiva	4.079	0	5.724	0	3.787	0	4.583	0	4.048	0	9.760	0
Vila Nova de Poiares	4.594	0	6.126	0	4.267	0	4.998	0	4.846	0	10.805	0
Vila Pouca de Aguiar	3.911	0	5.600	0	3.631	0	4.457	0	3.798	0	9.444	1
Vila Real	4.022	0	5.681	2	3.734	0	4.540	2	3.963	0	9.652	4
Vila Real de Santo António	3.442	0	5.270	0	3.194	0	4.124	0	3.130	0	8.622	1
Vila Velha de Ródão	4.104	0	5.743	0	3.811	0	4.603	0	4.086	0	9.808	0
Vila Verde	4.498	0	6.048	2	4.177	0	4.918	2	4.693	0	10.601	4
Vila Viçosa	3.799	0	5.518	0	3.526	0	4.374	0	3.634	0	9.240	0
Vimioso	3.216	0	5.119	0	2.984	0	3.974	0	2.824	0	8.256	0
Vinhais	3.440	0	5.268	0	3.192	0	4.123	0	3.127	0	8.619	0
Viseu	4.247	0	5.852	5	3.944	0	4.714	4	4.303	0	10.088	9
Vizela	4.419	0	5.985	1	4.104	0	4.852	1	4.569	0	10.436	2
Vouzela	4.413	0	5.981	0	4.099	0	4.848	0	4.560	0	10.425	1

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
1	0.250	8844	5.024	177	2.933	0	0.470	16627	9.45	334	3.683	0	1.000	35376	20.10	710	1.825	0
2	0.250	11497	5.584	256	3.001	0	0.470	21616	10.50	482	3.890	0	1.000	45991	22.34	1027	2.136	0
3	0.015	70	4.073	19	2.770	0	0.028	133	7.66	36	3.208	0	0.060	283	16.29	77	1.228	0
4	0.000	0	0.000	0	2.727	0	0.000	0	0.00	0	3.089	0	0.000	0	0.00	0	1.102	0
5	0.250	6031	5.638	136	3.007	0	0.470	11340	10.60	255	3.909	0	1.000	24127	22.55	544	2.166	0
6	0.017	701	4.079	167	2.772	0	0.032	1318	7.67	315	3.213	0	0.068	2806	16.32	670	1.234	0
7	0.250	2927	5.253	61	2.962	0	0.470	5504	9.87	115	3.770	0	1.000	11711	21.01	246	1.952	0
8	0.250	3215	6.390	82	3.085	0	0.470	6044	12.01	154	4.158	0	1.000	12860	25.56	328	2.586	0
9	0.250	13410	7.854	421	3.214	0	0.470	25211	14.76	791	4.590	0	1.000	53641	31.41	1685	3.435	0
10	0.250	4876	7.139	139	3.154	0	0.470	9167	13.42	261	4.386	0	1.000	19505	28.55	556	3.015	0
11	0.000	0	0.000	0	2.673	0	0.000	0	0.00	0	2.943	0	0.000	0	0.00	0	0.959	0
12	0.250	10899	7.690	335	3.200	0	0.470	20490	14.46	630	4.544	0	1.000	43596	30.76	1340	3.338	0
13	0.000	0	0.000	0	2.659	0	0.000	0	0.00	0	2.905	0	0.000	0	0.00	0	0.924	0
14	0.000	0	0.000	0	2.741	0	0.000	0	0.00	0	3.128	0	0.000	0	0.00	0	1.143	0
15	0.250	1399	4.941	27	2.922	0	0.470	2631	9.29	52	3.650	0	1.000	5598	19.76	110	1.779	0
16	0.242	2008	4.330	35	2.828	0	0.456	3776	8.14	67	3.373	0	0.970	8035	17.32	143	1.419	0
17	0.250	42246	8.065	1362	3.231	0	0.470	79423	15.16	2562	4.648	0	1.000	168987	32.26	5451	3.562	0
18	0.000	0	0.000	0	2.666	0	0.000	0	0.00	0	2.924	0	0.000	0	0.00	0	0.941	0
19	0.250	5642	6.093	137	3.055	0	0.470	10607	11.46	258	4.063	0	1.000	22569	24.37	550	2.420	0
20	0.022	146	4.089	27	2.775	0	0.041	274	7.69	51	3.222	0	0.087	584	16.36	110	1.243	0
21	0.250	1771	5.998	42	3.045	0	0.470	3330	11.28	79	4.031	0	1.000	7087	23.99	170	2.367	0
22	0.091	289	4.162	13	2.794	0	0.170	544	7.82	24	3.275	0	0.363	1157	16.65	53	1.303	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} [10^{-3}]	C_{ϕ^-}	V_e [10^{-8}]	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} [10^{-3}]	C_{ϕ^-}	V_e [10^{-10}]	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} [10^{-3}]	C_{ϕ^-}	V_e [10^{-13}]	C_e
23	0.250	1656	5.516	36	2.993	0	0.470	3114	10.37	68	3.866	0	1.000	6625	22.07	146	2.099	0
24	0.228	561	4.282	10	2.819	0	0.429	1055	8.05	19	3.347	0	0.912	2246	17.13	42	1.387	0
25	0.250	45431	8.703	1581	3.279	0	0.470	85410	16.36	2973	4.819	0	1.000	181724	34.81	6326	3.951	0
26	0.250	13338	4.547	242	2.865	0	0.470	25076	8.55	456	3.481	0	1.000	53354	18.19	970	1.552	0
27	0.250	4528	4.813	87	2.905	0	0.470	8513	9.05	163	3.597	0	1.000	18113	19.25	348	1.706	0
28	0.250	6824	5.598	152	3.002	0	0.470	12830	10.52	287	3.895	0	1.000	27297	22.39	611	2.144	0
29	0.000	0	0.000	0	2.619	0	0.000	0	0.00	0	2.802	0	0.000	0	0.00	0	0.833	0
30	0.250	3026	5.679	68	3.011	0	0.470	5689	10.68	129	3.923	0	1.000	12105	22.71	274	2.189	0
31	0.250	5242	4.778	100	2.900	0	0.470	9855	8.98	188	3.582	0	1.000	20969	19.11	400	1.686	0
32	0.250	2766	4.764	52	2.898	0	0.470	5201	8.96	99	3.577	0	1.000	11067	19.06	210	1.678	0
33	0.064	370	4.141	23	2.789	0	0.120	696	7.79	45	3.261	0	0.256	1481	16.57	95	1.287	0
34	0.250	5215	4.968	103	2.926	0	0.470	9804	9.34	194	3.660	0	1.000	20860	19.87	414	1.793	0
35	0.249	1731	4.433	30	2.847	0	0.469	3254	8.33	57	3.426	0	0.997	6924	17.73	123	1.483	0
36	0.000	0	0.000	0	2.721	0	0.000	0	0.00	0	3.072	0	0.000	0	0.00	0	1.085	0
37	0.250	3770	7.999	120	3.225	0	0.470	7088	15.04	226	4.630	0	1.000	15082	32.00	482	3.522	0
38	0.250	19479	6.183	481	3.064	0	0.470	36620	11.62	905	4.092	0	1.000	77916	24.73	1927	2.470	0
39	0.248	1055	4.396	18	2.840	0	0.467	1983	8.26	35	3.407	0	0.993	4220	17.58	74	1.460	0
40	0.250	5611	7.007	157	3.142	0	0.470	10549	13.17	295	4.347	0	1.000	22445	28.03	629	2.939	0
41	0.250	4720	4.517	85	2.861	0	0.470	8874	8.49	160	3.466	0	1.000	18882	18.07	341	1.534	0
42	0.250	29132	5.446	634	2.985	0	0.470	54769	10.24	1193	3.841	0	1.000	116530	21.79	2538	2.060	0
43	0.000	0	0.000	0	2.638	0	0.000	0	0.00	0	2.851	0	0.000	0	0.00	0	0.875	0
44	0.250	18854	7.578	571	3.191	0	0.470	35446	14.25	1074	4.512	0	1.000	75419	30.31	2285	3.271	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
45	0.250	3960	7.107	112	3.151	0	0.470	7444	13.36	211	4.377	0	1.000	15840	28.43	450	2.997	0
46	0.023	778	4.092	137	2.776	0	0.044	1463	7.69	258	3.224	0	0.093	3114	16.37	549	1.246	0
47	0.000	0	0.000	0	2.743	0	0.000	0	0.00	0	3.131	0	0.000	0	0.00	0	1.146	0
48	0.250	7553	6.673	201	3.112	0	0.470	14200	12.55	379	4.246	0	1.000	30214	26.69	806	2.747	0
49	0.250	3133	8.786	110	3.285	0	0.470	5890	16.52	207	4.841	0	1.000	12533	35.14	440	4.002	0
50	0.000	0	0.000	0	2.741	0	0.000	0	0.00	0	3.126	0	0.000	0	0.00	0	1.140	0
51	0.006	28	4.033	20	2.755	0	0.011	54	7.58	38	3.166	0	0.023	115	16.13	81	1.183	0
52	0.250	45479	4.996	908	2.930	0	0.470	85501	9.39	1708	3.671	0	1.000	181918	19.98	3635	1.809	0
53	0.000	0	0.000	0	2.617	0	0.000	0	0.00	0	2.797	0	0.000	0	0.00	0	0.828	0
54	0.243	3819	4.335	68	2.829	0	0.457	7180	8.15	127	3.376	0	0.973	15277	17.34	272	1.422	0
55	0.250	3406	8.408	114	3.257	0	0.470	6404	15.81	215	4.741	0	1.000	13627	33.63	458	3.770	0
56	0.250	12885	8.761	451	3.284	0	0.470	24223	16.47	848	4.834	0	1.000	51540	35.04	1806	3.987	0
57	0.000	0	0.000	0	2.532	0	0.000	0	0.00	0	2.582	0	0.000	0	0.00	0	0.659	0
58	0.250	2716	4.639	50	2.880	0	0.470	5106	8.72	94	3.522	0	1.000	10864	18.56	201	1.606	0
59	0.250	8430	4.529	152	2.862	0	0.470	15848	8.51	287	3.472	0	1.000	33721	18.11	611	1.541	0
60	0.250	3968	5.697	90	3.013	0	0.470	7460	10.71	169	3.929	0	1.000	15872	22.79	361	2.199	0
61	0.000	0	0.000	0	2.682	0	0.000	0	0.00	0	2.967	0	0.000	0	0.00	0	0.981	0
62	0.250	8767	6.127	214	3.059	0	0.470	16481	11.52	403	4.074	0	1.000	35068	24.51	859	2.439	0
63	0.000	0	0.000	0	2.714	0	0.000	0	0.00	0	3.054	0	0.000	0	0.00	0	1.066	0
64	0.250	2322	4.641	43	2.880	0	0.470	4366	8.72	81	3.523	0	1.000	9289	18.56	172	1.607	0
65	0.250	5935	6.718	159	3.116	0	0.470	11157	12.63	299	4.260	0	1.000	23740	26.87	637	2.773	0
66	0.250	53118	9.943	2112	3.366	0	0.470	99862	18.69	3971	5.133	0	1.000	212474	39.77	8450	4.737	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
67	0.250	662	5.096	13	2.942	0	0.470	1245	9.58	25	3.710	0	1.000	2649	20.38	54	1.865	0
68	0.016	821	4.075	212	2.771	0	0.030	1543	7.66	399	3.210	0	0.063	3285	16.30	850	1.230	0
69	0.250	3891	4.952	77	2.924	0	0.470	7316	9.31	144	3.654	0	1.000	15566	19.81	308	1.785	0
70	0.007	19	4.040	11	2.758	0	0.013	37	7.60	22	3.175	0	0.027	79	16.16	47	1.192	0
71	0.250	3475	4.450	61	2.850	0	0.469	6533	8.37	116	3.434	0	0.998	13901	17.80	247	1.494	0
72	0.000	0	0.000	0	2.653	0	0.000	0	0.00	0	2.889	0	0.000	0	0.00	0	0.909	0
73	0.105	731	4.172	28	2.796	0	0.198	1375	7.84	54	3.281	0	0.421	2926	16.69	115	1.310	0
74	0.004	28	4.019	28	2.746	0	0.008	53	7.56	52	3.140	0	0.016	113	16.08	112	1.155	0
75	0.248	4735	4.394	83	2.840	0	0.467	8902	8.26	157	3.406	0	0.993	18941	17.58	335	1.459	0
76	0.250	2313	5.719	52	3.016	0	0.470	4348	10.75	99	3.937	0	1.000	9252	22.88	211	2.211	0
77	0.000	0	0.000	0	2.719	0	0.000	0	0.00	0	3.067	0	0.000	0	0.00	0	1.079	0
78	0.250	4617	4.633	85	2.879	0	0.470	8680	8.71	160	3.519	0	1.000	18469	18.53	342	1.602	0
79	0.250	33430	5.610	750	3.004	0	0.470	62850	10.55	1410	3.899	0	1.000	133723	22.44	3000	2.151	0
80	0.250	4399	5.859	103	3.031	0	0.470	8270	11.01	193	3.985	0	1.000	17596	23.44	412	2.289	0
81	0.250	1000	5.339	21	2.972	0	0.470	1880	10.04	40	3.802	0	1.000	4001	21.35	85	2.000	0
82	0.250	4407	5.670	99	3.010	0	0.470	8285	10.66	187	3.920	0	1.000	17628	22.68	399	2.184	0
83	0.000	0	0.000	0	2.367	0	0.000	0	0.00	0	2.195	0	0.000	0	0.00	0	0.414	0
84	0.018	846	4.081	192	2.773	0	0.034	1590	7.67	361	3.215	0	0.072	3384	16.32	769	1.236	0
85	0.090	285	4.161	13	2.794	0	0.168	536	7.82	24	3.274	0	0.358	1141	16.64	53	1.302	0
86	0.081	371	4.155	19	2.792	0	0.152	698	7.81	35	3.270	0	0.323	1485	16.62	76	1.297	0
87	0.000	0	0.000	0	2.693	0	0.000	0	0.00	0	2.997	0	0.000	0	0.00	0	1.011	0
88	0.250	5303	5.708	121	3.014	0	0.470	9970	10.73	227	3.933	0	1.000	21213	22.83	484	2.205	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
89	0.250	7370	5.943	175	3.040	0	0.470	13857	11.17	329	4.013	0	1.000	29483	23.77	700	2.336	0
90	0.250	8514	5.913	201	3.036	0	0.470	16006	11.12	378	4.003	0	1.000	34056	23.65	805	2.319	0
91	0.250	6491	5.882	152	3.033	0	0.470	12203	11.06	287	3.993	0	1.000	25964	23.53	610	2.302	0
92	0.012	149	4.063	52	2.767	0	0.022	281	7.64	97	3.199	0	0.047	599	16.25	208	1.218	0
93	0.226	11876	4.279	224	2.819	0	0.426	22328	8.04	421	3.345	0	0.906	47507	17.12	897	1.385	0
94	0.250	12066	4.601	222	2.874	0	0.470	22685	8.65	417	3.505	0	1.000	48267	18.41	888	1.584	0
95	0.000	0	0.000	0	2.710	0	0.000	0	0.00	0	3.042	0	0.000	0	0.00	0	1.055	0
96	0.250	14143	4.683	264	2.886	0	0.470	26590	8.80	498	3.541	0	1.000	56575	18.73	1059	1.631	0
97	0.209	1643	4.253	33	2.814	0	0.394	3089	8.00	62	3.330	0	0.837	6572	17.01	133	1.368	0
98	0.250	1997	5.275	42	2.965	0	0.470	3754	9.92	79	3.778	0	1.000	7988	21.10	168	1.965	0
99	0.250	14716	7.281	428	3.166	0	0.470	27667	13.69	805	4.427	0	1.000	58866	29.12	1714	3.097	0
100	0.000	0	0.000	0	2.671	0	0.000	0	0.00	0	2.937	0	0.000	0	0.00	0	0.954	0
101	0.250	1401	5.247	29	2.961	0	0.470	2635	9.87	55	3.768	0	1.000	5607	20.99	117	1.950	0
102	0.020	93	4.087	18	2.774	0	0.038	175	7.68	35	3.220	0	0.082	372	16.35	74	1.241	0
103	0.000	0	0.000	0	2.645	0	0.000	0	0.00	0	2.868	0	0.000	0	0.00	0	0.890	0
104	0.057	168	4.135	12	2.787	0	0.106	317	7.77	23	3.256	0	0.226	675	16.54	49	1.282	0
105	0.250	26003	4.475	465	2.854	0	0.469	48887	8.41	876	3.446	0	0.999	104015	17.90	1863	1.509	0
106	0.019	500	4.083	109	2.773	0	0.035	941	7.68	205	3.216	0	0.075	2003	16.33	436	1.238	0
107	0.250	836	4.535	15	2.863	0	0.470	1572	8.53	28	3.475	0	1.000	3346	18.14	60	1.545	0
108	0.250	956	4.876	18	2.914	0	0.470	1797	9.17	35	3.623	0	1.000	3824	19.50	74	1.742	0
109	0.250	1343	5.749	30	3.019	0	0.470	2526	10.81	58	3.947	0	1.000	5374	23.00	123	2.228	0
110	0.250	41407	5.531	916	2.995	0	0.470	77846	10.40	1722	3.871	0	1.000	165630	22.12	3664	2.107	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

ID	best						expected						worst					
	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
111	0.057	706	4.135	51	2.787	0	0.106	1327	7.77	97	3.256	0	0.226	2824	16.54	206	1.282	0
112	0.250	3642	5.226	76	2.959	0	0.470	6847	9.83	143	3.760	0	1.000	14569	20.90	304	1.938	0
113	0.000	0	0.000	0	2.726	0	0.000	0	0.00	0	3.085	0	0.000	0	0.00	0	1.097	0
114	0.250	38197	4.822	736	2.906	0	0.470	71812	9.07	1385	3.601	0	1.000	152791	19.29	2947	1.711	0
115	0.000	0	0.000	0	2.482	0	0.000	0	0.00	0	2.460	0	0.000	0	0.00	0	0.573	0
116	0.000	0	0.000	0	2.725	0	0.000	0	0.00	0	3.083	0	0.000	0	0.00	0	1.096	0
117	0.250	9601	6.283	241	3.074	0	0.470	18050	11.81	453	4.124	0	1.000	38405	25.13	965	2.527	0
118	0.250	3666	4.482	65	2.855	0	0.470	6893	8.43	123	3.450	0	0.999	14667	17.93	263	1.513	0
119	0.222	5044	4.271	97	2.817	0	0.417	9482	8.03	182	3.341	0	0.887	20176	17.08	388	1.380	0
120	0.250	7607	4.524	137	2.862	0	0.470	14302	8.51	258	3.470	0	1.000	30431	18.10	550	1.538	0
121	0.000	0	0.000	0	2.364	0	0.000	0	0.00	0	2.188	0	0.000	0	0.00	0	0.410	0
122	0.000	0	0.000	0	2.637	0	0.000	0	0.00	0	2.848	0	0.000	0	0.00	0	0.873	0
123	0.210	5240	4.254	106	2.814	0	0.395	9851	8.00	199	3.331	0	0.840	20960	17.01	424	1.368	0
124	0.250	31214	7.033	878	3.144	0	0.470	58682	13.22	1650	4.355	0	1.000	124857	28.13	3512	2.953	0
125	0.250	126805	7.984	4049	3.224	0	0.470	238393	15.01	7613	4.626	0	1.000	507220	31.94	16198	3.513	0
126	0.000	0	0.000	0	2.735	0	0.000	0	0.00	0	3.110	0	0.000	0	0.00	0	1.124	0
127	0.250	52839	8.348	1764	3.253	0	0.470	99338	15.69	3317	4.725	0	1.000	211359	33.39	7057	3.733	0
128	0.250	6417	9.938	255	3.366	0	0.470	12064	18.68	479	5.132	0	1.000	25670	39.75	1020	4.734	0
129	0.250	4281	5.174	88	2.952	0	0.470	8050	9.73	166	3.741	0	1.000	17127	20.70	354	1.909	0
130	0.250	11697	4.879	228	2.914	0	0.470	21991	9.17	429	3.624	0	1.000	46789	19.52	913	1.744	0
131	0.250	1580	4.643	29	2.880	0	0.470	2971	8.73	55	3.524	0	1.000	6322	18.57	117	1.608	0
132	0.000	0	0.000	0	2.652	0	0.000	0	0.00	0	2.888	0	0.000	0	0.00	0	0.909	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
133	0.250	5023	4.676	93	2.885	0	0.470	9444	8.79	176	3.538	0	1.000	20093	18.70	375	1.627	0
134	0.000	0	0.000	0	2.489	0	0.000	0	0.00	0	2.477	0	0.000	0	0.00	0	0.585	0
135	0.250	21002	9.620	808	3.344	0	0.470	39483	18.09	1519	5.053	0	1.000	84008	38.48	3232	4.529	0
136	0.250	34431	5.708	786	3.014	0	0.470	64731	10.73	1477	3.933	0	1.000	137726	22.83	3144	2.205	0
137	0.231	4291	4.288	79	2.820	0	0.433	8068	8.06	150	3.350	0	0.922	17166	17.15	319	1.391	0
138	0.028	84	4.100	12	2.778	0	0.052	159	7.71	23	3.231	0	0.112	338	16.40	49	1.253	0
139	0.250	12915	4.687	242	2.887	0	0.470	24280	8.81	455	3.543	0	1.000	51660	18.75	968	1.634	0
140	0.250	9601	7.661	294	3.198	0	0.470	18049	14.40	553	4.536	0	1.000	38404	30.65	1176	3.321	0
141	0.000	0	0.000	0	2.744	0	0.000	0	0.00	0	3.134	0	0.000	0	0.00	0	1.148	0
142	0.250	43595	5.959	1039	3.041	0	0.470	81959	11.20	1953	4.018	0	1.000	174381	23.84	4156	2.345	0
143	0.250	4972	5.662	112	3.009	0	0.470	9349	10.64	211	3.917	0	1.000	19891	22.65	450	2.179	0
144	0.000	0	0.000	0	2.716	0	0.000	0	0.00	0	3.057	0	0.000	0	0.00	0	1.070	0
145	0.248	2022	4.397	35	2.840	0	0.467	3802	8.27	67	3.408	0	0.993	8090	17.59	143	1.461	0
146	0.000	0	0.000	0	2.714	0	0.000	0	0.00	0	3.052	0	0.000	0	0.00	0	1.065	0
147	0.237	948	4.308	17	2.824	0	0.446	1783	8.10	32	3.361	0	0.950	3795	17.23	68	1.404	0
148	0.250	2957	6.632	78	3.108	0	0.470	5560	12.47	147	4.234	0	1.000	11831	26.53	313	2.724	0
149	0.250	3171	5.387	68	2.978	0	0.470	5962	10.13	128	3.820	0	1.000	12686	21.55	273	2.027	0
150	0.000	0	0.000	0	2.572	0	0.000	0	0.00	0	2.683	0	0.000	0	0.00	0	0.735	0
151	0.000	0	0.000	0	2.686	0	0.000	0	0.00	0	2.979	0	0.000	0	0.00	0	0.993	0
152	0.000	0	0.000	0	2.626	0	0.000	0	0.00	0	2.820	0	0.000	0	0.00	0	0.848	0
153	0.030	289	4.103	39	2.779	0	0.056	544	7.71	75	3.233	0	0.119	1158	16.41	159	1.256	0
154	0.250	16131	7.156	461	3.155	0	0.470	30327	13.45	868	4.391	0	1.000	64526	28.62	1846	3.025	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} [10^{-3}]	C_{ϕ^-}	V_e [10^{-8}]	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} [10^{-3}]	C_{ϕ^-}	V_e [10^{-10}]	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} [10^{-3}]	C_{ϕ^-}	V_e [10^{-13}]	C_e
155	0.250	4475	4.736	84	2.894	0	0.470	8413	8.90	159	3.564	0	1.000	17901	18.94	339	1.662	0
156	0.250	1294	4.517	23	2.861	0	0.470	2434	8.49	44	3.466	0	1.000	5179	18.07	93	1.534	0
157	0.242	1692	4.329	30	2.828	0	0.455	3181	8.14	56	3.373	0	0.969	6768	17.32	120	1.418	0
158	0.004	12	4.019	12	2.746	0	0.008	22	7.56	22	3.141	0	0.016	48	16.08	48	1.156	0
159	0.014	130	4.071	37	2.770	0	0.027	245	7.65	69	3.207	0	0.057	521	16.29	148	1.227	0
160	0.250	3934	4.775	75	2.899	0	0.470	7397	8.98	141	3.581	0	1.000	15739	19.10	300	1.684	0
161	0.250	6307	6.510	164	3.096	0	0.470	11858	12.24	308	4.196	0	1.000	25230	26.04	657	2.655	0
162	0.250	14221	7.145	406	3.154	0	0.470	26736	13.43	764	4.388	0	1.000	56887	28.58	1625	3.018	0
163	0.250	1046	4.801	20	2.903	0	0.470	1968	9.03	37	3.592	0	1.000	4187	19.21	80	1.699	0
164	0.250	2213	5.101	45	2.943	0	0.470	4162	9.59	84	3.713	0	1.000	8855	20.41	180	1.868	0
165	0.000	0	0.000	0	2.709	0	0.000	0	0.00	0	3.039	0	0.000	0	0.00	0	1.051	0
166	0.000	0	0.000	0	2.703	0	0.000	0	0.00	0	3.024	0	0.000	0	0.00	0	1.037	0
167	0.000	0	0.000	0	2.733	0	0.000	0	0.00	0	3.104	0	0.000	0	0.00	0	1.117	0
168	0.250	2561	6.106	62	3.056	0	0.470	4814	11.48	117	4.067	0	1.000	10244	24.42	250	2.427	0
169	0.250	3545	8.411	119	3.257	0	0.470	6664	15.81	224	4.742	0	1.000	14180	33.65	477	3.772	0
170	0.249	3241	4.408	57	2.842	0	0.468	6093	8.29	107	3.414	0	0.995	12964	17.63	229	1.468	0
171	0.127	783	4.187	25	2.800	0	0.239	1472	7.87	48	3.290	0	0.510	3132	16.75	102	1.321	0
172	0.250	1218	5.382	26	2.977	0	0.470	2291	10.12	49	3.818	0	1.000	4874	21.53	104	2.024	0
173	0.250	2929	8.854	103	3.290	0	0.470	5507	16.65	195	4.858	0	1.000	11719	35.42	415	4.045	0
174	0.250	6155	4.884	120	2.915	0	0.470	11571	9.18	226	3.627	0	1.000	24620	19.54	481	1.747	0
175	0.250	39900	8.420	1343	3.258	0	0.470	75012	15.83	2526	4.744	0	1.000	159602	33.68	5375	3.777	0
176	0.250	44054	9.074	1598	3.306	0	0.470	82822	17.06	3006	4.915	0	1.000	176218	36.29	6395	4.182	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
177	0.250	1260	4.539	22	2.864	0	0.470	2370	8.53	43	3.477	0	1.000	5043	18.15	91	1.547	0
178	0.000	0	0.000	0	2.697	0	0.000	0	0.00	0	3.006	0	0.000	0	0.00	0	1.019	0
179	0.250	16528	5.555	367	2.997	0	0.470	31073	10.44	690	3.880	0	1.000	66112	22.22	1469	2.120	0
180	0.250	2479	4.895	48	2.916	0	0.470	4662	9.20	91	3.631	0	1.000	9919	19.58	194	1.753	0
181	0.250	5985	5.749	137	3.019	0	0.470	11253	10.81	258	3.948	0	1.000	23943	23.00	550	2.228	0
182	0.249	4821	4.440	85	2.848	0	0.469	9063	8.35	161	3.430	0	0.998	19284	17.76	343	1.488	0
183	0.250	11017	6.157	271	3.062	0	0.470	20711	11.57	510	4.083	0	1.000	44068	24.63	1085	2.456	0
184	0.233	1084	4.295	19	2.822	0	0.438	2039	8.07	37	3.354	0	0.933	4339	17.18	79	1.395	0
185	0.250	13529	5.992	324	3.045	0	0.470	25436	11.27	609	4.029	0	1.000	54119	23.97	1297	2.363	0
186	0.250	14177	5.075	287	2.940	0	0.470	26653	9.54	541	3.702	0	1.000	56708	20.30	1151	1.853	0
187	0.250	16053	6.669	428	3.111	0	0.470	30180	12.54	805	4.245	0	1.000	64214	26.67	1712	2.745	0
188	0.250	1012	4.598	18	2.873	0	0.470	1904	8.64	35	3.504	0	1.000	4051	18.39	74	1.582	0
189	0.250	21517	5.020	432	2.933	0	0.470	40453	9.44	812	3.681	0	1.000	86071	20.08	1728	1.823	0
190	0.250	2139	5.012	42	2.932	0	0.470	4023	9.42	80	3.678	0	1.000	8559	20.05	171	1.818	0
191	0.250	857	4.956	16	2.924	0	0.470	1611	9.32	31	3.656	0	1.000	3428	19.83	67	1.787	0
192	0.250	3452	5.240	72	2.960	0	0.470	6491	9.85	136	3.765	0	1.000	13811	20.96	289	1.945	0
193	0.250	17480	4.920	344	2.919	0	0.470	32863	9.25	646	3.641	0	1.000	69921	19.68	1376	1.766	0
194	0.165	1183	4.212	30	2.805	0	0.310	2225	7.92	56	3.306	0	0.660	4735	16.85	120	1.340	0
195	0.000	0	0.000	0	2.713	0	0.000	0	0.00	0	3.050	0	0.000	0	0.00	0	1.062	0
196	0.000	0	0.000	0	2.738	0	0.000	0	0.00	0	3.117	0	0.000	0	0.00	0	1.131	0
197	0.250	1359	5.526	30	2.994	0	0.470	2556	10.39	56	3.870	0	1.000	5438	22.11	120	2.104	0
198	0.250	6621	10.629	281	3.411	0	0.470	12448	19.98	529	5.299	0	1.000	26487	42.52	1126	5.190	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
199	0.170	2684	4.216	66	2.806	0	0.319	5047	7.93	125	3.309	0	0.678	10738	16.86	266	1.342	0
200	0.000	0	0.000	0	2.689	0	0.000	0	0.00	0	2.985	0	0.000	0	0.00	0	0.999	0
201	0.250	12921	6.317	326	3.078	0	0.470	24291	11.88	613	4.135	0	1.000	51684	25.27	1305	2.545	0
202	0.245	16644	4.351	295	2.832	0	0.461	31291	8.18	555	3.384	0	0.981	66577	17.40	1180	1.432	0
203	0.250	2135	4.577	39	2.870	0	0.470	4015	8.60	73	3.494	0	1.000	8543	18.31	156	1.569	0
204	0.250	2802	4.816	53	2.905	0	0.470	5268	9.05	101	3.599	0	1.000	11209	19.27	215	1.708	0
205	0.250	10374	5.179	214	2.953	0	0.470	19504	9.74	404	3.742	0	1.000	41498	20.72	859	1.911	0
206	0.250	3772	4.616	69	2.876	0	0.470	7092	8.68	130	3.512	0	1.000	15091	18.46	278	1.593	0
207	0.005	106	4.026	90	2.751	0	0.009	200	7.57	169	3.155	0	0.019	425	16.10	360	1.171	0
208	0.009	53	4.052	23	2.763	0	0.017	100	7.62	44	3.189	0	0.037	214	16.21	95	1.207	0
209	0.247	13688	4.371	242	2.836	0	0.464	25733	8.22	455	3.394	0	0.988	54752	17.48	968	1.444	0
210	0.250	53820	5.748	1237	3.019	0	0.470	101183	10.81	2326	3.947	0	1.000	215283	22.99	4949	2.227	0
211	0.250	5822	7.062	164	3.147	0	0.470	10945	13.28	309	4.363	0	1.000	23288	28.25	657	2.971	0
212	0.250	587	5.013	11	2.932	0	0.470	1104	9.42	22	3.678	0	1.000	2349	20.05	47	1.819	0
213	0.250	1293	5.585	28	3.001	0	0.470	2432	10.50	54	3.890	0	1.000	5175	22.34	115	2.137	0
214	0.250	5361	4.701	100	2.889	0	0.470	10079	8.84	189	3.549	0	1.000	21445	18.80	403	1.642	0
215	0.250	15627	6.012	375	3.047	0	0.470	29379	11.30	706	4.036	0	1.000	62510	24.05	1503	2.374	0
216	0.250	1488	5.079	30	2.940	0	0.470	2798	9.55	56	3.704	0	1.000	5953	20.32	120	1.856	0
217	0.250	1847	4.548	33	2.866	0	0.470	3472	8.55	63	3.481	0	1.000	7388	18.19	134	1.552	0
218	0.005	30	4.026	25	2.751	0	0.009	56	7.57	48	3.155	0	0.019	121	16.10	102	1.171	0
219	0.000	0	0.000	0	2.738	0	0.000	0	0.00	0	3.120	0	0.000	0	0.00	0	1.134	0
220	0.249	2553	4.439	45	2.848	0	0.469	4801	8.35	85	3.429	0	0.998	10215	17.76	181	1.487	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
221	0.250	3102	4.555	56	2.867	0	0.470	5832	8.56	106	3.484	0	1.000	12408	18.22	226	1.557	0
222	0.072	432	4.148	25	2.791	0	0.135	813	7.80	47	3.265	0	0.287	1730	16.59	100	1.292	0
223	0.250	8174	4.616	150	2.876	0	0.470	15367	8.68	283	3.512	0	1.000	32696	18.46	603	1.593	0
224	0.250	5085	7.538	153	3.188	0	0.470	9559	14.17	288	4.501	0	1.000	20340	30.15	613	3.248	0
225	0.007	44	4.044	23	2.760	0	0.014	83	7.60	44	3.180	0	0.030	176	16.18	95	1.197	0
226	0.000	0	0.000	0	2.699	0	0.000	0	0.00	0	3.012	0	0.000	0	0.00	0	1.025	0
227	0.250	5317	6.652	141	3.110	0	0.470	9995	12.51	265	4.240	0	1.000	21268	26.61	565	2.735	0
228	0.250	2626	4.889	51	2.915	0	0.470	4937	9.19	96	3.628	0	1.000	10505	19.56	205	1.749	0
229	0.250	11184	4.584	205	2.871	0	0.470	21027	8.62	385	3.497	0	1.000	44739	18.33	820	1.574	0
230	0.000	0	0.000	0	2.541	0	0.000	0	0.00	0	2.604	0	0.000	0	0.00	0	0.675	0
231	0.000	0	0.000	0	2.366	0	0.000	0	0.00	0	2.192	0	0.000	0	0.00	0	0.412	0
232	0.250	34631	5.714	791	3.015	0	0.470	65106	10.74	1488	3.935	0	1.000	138524	22.86	3166	2.208	0
233	0.173	1149	4.218	28	2.806	0	0.325	2160	7.93	52	3.310	0	0.691	4597	16.87	112	1.344	0
234	0.250	1687	4.845	32	2.909	0	0.470	3172	9.11	61	3.610	0	1.000	6749	19.38	130	1.724	0
235	0.250	14349	6.346	364	3.080	0	0.470	26977	11.93	684	4.144	0	1.000	57398	25.39	1457	2.562	0
236	0.250	7181	5.401	155	2.980	0	0.470	13500	10.15	291	3.825	0	1.000	28724	21.60	620	2.035	0
237	0.250	17055	5.260	358	2.963	0	0.470	32063	9.89	674	3.773	0	1.000	68220	21.04	1435	1.957	0
238	0.000	0	0.000	0	2.714	0	0.000	0	0.00	0	3.053	0	0.000	0	0.00	0	1.066	0
239	0.250	5440	5.591	121	3.001	0	0.470	10227	10.51	228	3.892	0	1.000	21760	22.36	486	2.140	0
240	0.000	0	0.000	0	2.734	0	0.000	0	0.00	0	3.108	0	0.000	0	0.00	0	1.122	0
241	0.250	3871	4.701	72	2.889	0	0.470	7279	8.84	136	3.549	0	1.000	15487	18.80	291	1.642	0
242	0.249	811	4.403	14	2.842	0	0.467	1525	8.28	27	3.411	0	0.994	3245	17.61	57	1.464	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
243	0.250	1287	4.850	24	2.910	0	0.470	2420	9.12	46	3.613	0	1.000	5149	19.40	99	1.727	0
244	0.250	934	4.955	18	2.924	0	0.470	1757	9.31	34	3.655	0	1.000	3738	19.82	74	1.786	0
245	0.196	2273	4.238	49	2.811	0	0.368	4273	7.97	92	3.322	0	0.784	9092	16.95	196	1.358	0
246	0.207	4643	4.250	95	2.813	0	0.389	8729	7.99	179	3.329	0	0.829	18572	17.00	381	1.366	0
247	0.250	41708	7.699	1284	3.201	0	0.470	78412	14.47	2414	4.547	0	1.000	166835	30.80	5137	3.343	0
248	0.007	36	4.040	21	2.758	0	0.013	67	7.59	40	3.175	0	0.027	144	16.16	87	1.192	0
249	0.000	0	0.000	0	2.723	0	0.000	0	0.00	0	3.077	0	0.000	0	0.00	0	1.089	0
250	0.250	3670	4.858	71	2.911	0	0.470	6900	9.13	134	3.616	0	1.000	14681	19.43	285	1.731	0
251	0.250	12889	7.413	382	3.177	0	0.470	24232	13.94	718	4.465	0	1.000	51559	29.65	1528	3.174	0
252	0.250	28939	6.623	766	3.107	0	0.470	54406	12.45	1441	4.231	0	1.000	115758	26.49	3066	2.719	0
253	0.250	2850	5.321	60	2.970	0	0.470	5359	10.00	114	3.795	0	1.000	11402	21.28	242	1.990	0
254	0.229	8295	4.285	155	2.820	0	0.431	15594	8.06	291	3.349	0	0.917	33180	17.14	620	1.389	0
255	0.250	3407	5.828	79	3.027	0	0.470	6406	10.96	149	3.974	0	1.000	13630	23.31	317	2.272	0
256	0.250	97108	9.784	3800	3.356	0	0.470	182563	18.39	7145	5.094	0	1.000	388434	39.14	15202	4.635	0
257	0.250	2622	8.483	88	3.263	0	0.470	4930	15.95	167	4.761	0	1.000	10490	33.93	355	3.816	0
258	0.250	4319	6.300	108	3.076	0	0.470	8120	11.84	204	4.130	0	1.000	17277	25.20	435	2.536	0
259	0.064	286	4.142	18	2.789	0	0.121	539	7.79	34	3.261	0	0.258	1147	16.57	73	1.287	0
260	0.250	2850	4.704	53	2.889	0	0.470	5359	8.84	100	3.551	0	1.000	11402	18.82	214	1.644	0
261	0.010	60	4.057	24	2.765	0	0.019	114	7.63	45	3.193	0	0.040	242	16.23	97	1.211	0
262	0.199	1545	4.242	32	2.811	0	0.374	2905	7.97	61	3.324	0	0.797	6181	16.97	131	1.360	0
263	0.000	0	0.000	0	2.675	0	0.000	0	0.00	0	2.949	0	0.000	0	0.00	0	0.964	0
264	0.250	1601	4.689	30	2.887	0	0.470	3010	8.82	56	3.544	0	1.000	6404	18.76	120	1.635	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
265	0.250	9225	5.571	205	2.999	0	0.470	17343	10.47	386	3.886	0	1.000	36901	22.29	822	2.129	0
266	0.250	6636	4.771	126	2.899	0	0.470	12477	8.97	238	3.579	0	1.000	26547	19.08	506	1.682	0
267	0.000	0	0.000	0	2.677	0	0.000	0	0.00	0	2.954	0	0.000	0	0.00	0	0.969	0
268	0.250	8742	5.940	207	3.039	0	0.470	16435	11.17	390	4.012	0	1.000	34969	23.76	830	2.334	0
269	0.250	19555	9.312	728	3.323	0	0.470	36763	17.51	1369	4.976	0	1.000	78220	37.25	2913	4.332	0
270	0.000	0	0.000	0	2.735	0	0.000	0	0.00	0	3.112	0	0.000	0	0.00	0	1.125	0
271	0.250	9579	5.509	211	2.992	0	0.470	18008	10.36	396	3.864	0	1.000	38316	22.04	844	2.095	0
272	0.250	5671	6.358	144	3.082	0	0.470	10661	11.95	271	4.148	0	1.000	22685	25.43	576	2.569	0
273	0.250	5349	5.338	114	2.972	0	0.470	10057	10.04	214	3.802	0	1.000	21398	21.35	456	2.000	0
274	0.250	3320	5.079	67	2.940	0	0.470	6243	9.55	126	3.704	0	1.000	13282	20.32	269	1.856	0
275	0.250	24142	5.440	525	2.984	0	0.470	45387	10.23	987	3.839	0	1.000	96569	21.76	2101	2.056	0
276	0.000	0	0.000	0	2.700	0	0.000	0	0.00	0	3.016	0	0.000	0	0.00	0	1.029	0
277	0.000	0	0.000	0	2.516	0	0.000	0	0.00	0	2.544	0	0.000	0	0.00	0	0.631	0
278	0.250	2814	5.319	59	2.970	0	0.470	5291	10.00	112	3.795	0	1.000	11258	21.27	239	1.989	0
279	0.242	1242	4.325	22	2.828	0	0.454	2335	8.13	41	3.371	0	0.966	4969	17.30	88	1.416	0
280	0.250	21158	5.894	498	3.034	0	0.470	39778	11.08	937	3.997	0	1.000	84635	23.58	1995	2.309	0
281	0.024	133	4.094	22	2.777	0	0.046	250	7.70	42	3.226	0	0.097	532	16.38	90	1.248	0
282	0.250	2971	4.483	53	2.855	0	0.470	5586	8.43	100	3.450	0	0.999	11887	17.93	213	1.513	0
283	0.000	0	0.000	0	2.641	0	0.000	0	0.00	0	2.860	0	0.000	0	0.00	0	0.883	0
284	0.250	830	4.941	16	2.922	0	0.470	1560	9.29	30	3.650	0	1.000	3320	19.77	65	1.779	0
285	0.250	1288	4.903	25	2.917	0	0.470	2422	9.22	47	3.634	0	1.000	5153	19.61	101	1.757	0
286	0.250	19894	5.976	475	3.043	0	0.470	37402	11.23	894	4.024	0	1.000	79578	23.90	1902	2.354	0

Table D.3.4: 5km Impactor's thermal radiation and ejecta deposit vulnerabilities and casualties, for all studied municipalities (continuation)

	best						expected						worst					
ID	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-8}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-10}]$	C_e	V_{ϕ^+}	C_{ϕ^+}	V_{ϕ^-} $[10^{-3}]$	C_{ϕ^-}	V_e $[10^{-13}]$	C_e
287	0.250	1405	4.537	25	2.864	0	0.470	2642	8.53	47	3.476	0	1.000	5621	18.15	102	1.546	0
288	0.000	0	0.000	0	2.688	0	0.000	0	0.00	0	2.983	0	0.000	0	0.00	0	0.996	0
289	0.250	35400	7.491	1060	3.184	0	0.470	66553	14.08	1994	4.488	0	1.000	141603	29.97	4243	3.221	0
290	0.250	2769	4.676	51	2.885	0	0.470	5206	8.79	97	3.539	0	1.000	11077	18.71	207	1.628	0
291	0.250	1850	5.606	41	3.003	0	0.470	3478	10.54	78	3.898	0	1.000	7401	22.42	165	2.148	0
292	0.250	2219	5.380	47	2.977	0	0.470	4172	10.11	89	3.817	0	1.000	8876	21.52	191	2.023	0
293	0.250	32934	5.322	701	2.970	0	0.470	61916	10.01	1318	3.796	0	1.000	131737	21.29	2804	1.991	0
294	0.000	0	0.000	0	2.702	0	0.000	0	0.00	0	3.021	0	0.000	0	0.00	0	1.034	0
295	0.250	74984	5.778	1733	3.022	0	0.470	140970	10.86	3258	3.957	0	1.000	299937	23.11	6932	2.244	0
296	0.170	804	4.216	19	2.806	0	0.320	1512	7.93	37	3.309	0	0.681	3218	16.87	79	1.342	0
297	0.250	1732	5.193	35	2.955	0	0.470	3256	9.76	67	3.748	0	1.000	6928	20.77	143	1.919	0
298	0.008	98	4.048	48	2.762	0	0.015	184	7.61	91	3.184	0	0.033	393	16.19	194	1.202	0
299	0.073	3634	4.149	206	2.791	0	0.137	6832	7.80	388	3.266	0	0.292	14538	16.59	827	1.293	0
300	0.000	0	0.000	0	2.647	0	0.000	0	0.00	0	2.875	0	0.000	0	0.00	0	0.897	0
301	0.206	652	4.249	13	2.813	0	0.388	1227	7.99	25	3.328	0	0.825	2611	17.00	53	1.365	0
302	0.250	11716	4.965	232	2.925	0	0.470	22026	9.33	437	3.659	0	1.000	46864	19.86	930	1.792	0
303	0.000	0	0.000	0	2.733	0	0.000	0	0.00	0	3.105	0	0.000	0	0.00	0	1.118	0
304	0.000	0	0.000	0	2.598	0	0.000	0	0.00	0	2.746	0	0.000	0	0.00	0	0.786	0
305	0.000	0	0.000	0	2.647	0	0.000	0	0.00	0	2.874	0	0.000	0	0.00	0	0.896	0
306	0.250	24216	4.467	433	2.852	0	0.469	45526	8.40	814	3.443	0	0.999	96864	17.87	1733	1.504	0
307	0.250	5959	4.792	114	2.902	0	0.470	11204	9.01	214	3.588	0	1.000	23839	19.17	456	1.694	0
308	0.250	2415	4.781	46	2.900	0	0.470	4540	8.99	86	3.584	0	1.000	9660	19.12	184	1.688	0

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
1	0.997	35254	1.000	35366	1.000	35373	0.999	35344	1.000	35374	1.000	35375
2	1.000	45991	1.000	45991	1.000	45991	1.000	45991	1.000	45991	1.000	45992
3	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
4	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
5	1.000	24127	1.000	24127	1.000	24127	1.000	24127	1.000	24127	1.000	24127
6	1.000	41123	1.000	41123	1.000	41123	1.000	41123	1.000	41123	1.000	41123
7	1.000	11712	1.000	11712	1.000	11712	1.000	11712	1.000	11712	1.000	11712
8	0.991	12745	1.000	12859	1.000	12859	0.999	12845	1.000	12859	1.000	12859
9	1.000	53641	1.000	53641	1.000	53641	1.000	53641	1.000	53641	1.000	53641
10	1.000	19505	1.000	19505	1.000	19505	1.000	19505	1.000	19505	1.000	19505
11	0.967	2169	0.999	2241	1.000	2243	0.992	2225	1.000	2243	1.000	2243
12	1.000	43595	1.000	43595	1.000	43595	1.000	43595	1.000	43595	1.000	43595
13	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
14	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
15	1.000	5599	1.000	5599	1.000	5599	1.000	5599	1.000	5599	1.000	5599
16	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
17	1.000	168987	1.000	168987	1.000	168987	1.000	168987	1.000	168987	1.000	168987
18	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
19	1.000	22568	1.000	22568	1.000	22568	1.000	22568	1.000	22568	1.000	22568
20	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
21	1.000	7086	1.000	7086	1.000	7086	1.000	7086	1.000	7086	1.000	7086
22	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
23	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
24	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
25	1.000	181723	1.000	181723	1.000	181723	1.000	181724	1.000	181724	1.000	181724
26	0.021	1136	1.000	53365	1.000	53365	0.104	5560	1.000	53365	1.000	53365
27	1.000	18113	1.000	18113	1.000	18113	1.000	18113	1.000	18113	1.000	18113
28	1.000	27297	1.000	27297	1.000	27297	1.000	27297	1.000	27297	1.000	27297
29	1.000	33903	1.000	33903	1.000	33903	1.000	33903	1.000	33903	1.000	33903
30	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
31	1.000	20969	1.000	20969	1.000	20970	1.000	20969	1.000	20970	1.000	20970
32	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
33	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
34	0.093	1942	1.000	20860	1.000	20860	0.379	7912	1.000	20860	1.000	20860
35	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
36	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
37	0.782	11787	0.998	15048	1.000	15080	0.958	14441	1.000	15076	1.000	15081
38	1.000	77916	1.000	77915	1.000	77915	1.000	77916	1.000	77916	1.000	77915
39	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
40	1.000	22444	1.000	22444	1.000	22444	1.000	22444	1.000	22444	1.000	22444
41	0.000	0	0.000	0	0.000	0	0.016	294	1.000	18890	1.000	18890
42	1.000	116530	1.000	116531	1.000	116531	1.000	116531	1.000	116531	1.000	116531
43	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
44	1.000	75419	1.000	75419	1.000	75419	1.000	75419	1.000	75419	1.000	75419

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
45	1.000	15839	1.000	15839	1.000	15839	1.000	15839	1.000	15839	1.000	15840
46	0.862	28909	0.987	33128	0.997	33449	0.958	32124	0.996	33427	0.999	33518
47	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
48	1.000	30214	1.000	30214	1.000	30214	1.000	30214	1.000	30214	1.000	30214
49	1.000	12532	1.000	12532	1.000	12532	1.000	12532	1.000	12532	1.000	12532
50	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
51	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
52	1.000	181918	1.000	181918	1.000	181918	1.000	181918	1.000	181918	1.000	181918
53	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
54	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
55	0.834	11365	1.000	13626	1.000	13626	0.972	13243	1.000	13626	1.000	13626
56	1.000	51540	1.000	51540	1.000	51540	1.000	51540	1.000	51540	1.000	51540
57	1.000	3205	1.000	3205	1.000	3205	1.000	3205	1.000	3205	1.000	3205
58	1.000	10865	1.000	10865	1.000	10865	1.000	10865	1.000	10865	1.000	10865
59	1.000	33732	1.000	33732	1.000	33732	1.000	33732	1.000	33732	1.000	33732
60	1.000	15873	1.000	15873	1.000	15873	1.000	15873	1.000	15873	1.000	15873
61	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
62	1.000	35067	1.000	35067	1.000	35067	1.000	35067	1.000	35067	1.000	35067
63	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
64	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
65	1.000	23739	1.000	23739	1.000	23739	1.000	23739	1.000	23739	1.000	23739
66	1.000	212474	1.000	212474	1.000	212474	1.000	212474	1.000	212474	1.000	212474

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
67	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
68	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
69	1.000	15563	1.000	15566	1.000	15566	1.000	15566	1.000	15566	1.000	15566
70	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
71	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
72	1.000	6273	1.000	6273	1.000	6273	1.000	6273	1.000	6273	1.000	6273
73	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
74	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
75	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
76	1.000	9252	1.000	9252	1.000	9252	1.000	9252	1.000	9252	1.000	9252
77	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
78	1.000	18469	1.000	18469	1.000	18469	1.000	18469	1.000	18469	1.000	18469
79	1.000	133722	1.000	133723	1.000	133723	1.000	133723	1.000	133723	1.000	133723
80	1.000	17596	1.000	17596	1.000	17596	1.000	17596	1.000	17596	1.000	17596
81	0.999	3997	1.000	4001	1.000	4001	1.000	4001	1.000	4001	1.000	4001
82	1.000	17625	1.000	17628	1.000	17628	1.000	17627	1.000	17628	1.000	17628
83	1.000	65	1.000	65	1.000	65	1.000	65	1.000	65	1.000	65
84	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
85	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
86	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
87	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
88	0.999	21200	0.999	21200	0.999	21191	1.000	21211	1.000	21210	1.000	21207

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
89	1.000	29483	1.000	29483	1.000	29483	1.000	29483	1.000	29483	1.000	29483
90	1.000	34057	1.000	34057	1.000	34057	1.000	34057	1.000	34057	1.000	34057
91	1.000	25964	1.000	25964	1.000	25964	1.000	25964	1.000	25964	1.000	25964
92	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
93	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
94	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
95	1.000	60974	1.000	60974	1.000	60974	1.000	60974	1.000	60974	1.000	60974
96	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
97	0.998	7829	1.000	7846	1.000	7847	0.999	7844	1.000	7847	1.000	7847
98	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
99	1.000	58865	1.000	58865	1.000	58865	1.000	58865	1.000	58865	1.000	58865
100	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
101	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
102	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
103	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
104	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
105	1.000	104129	1.000	104129	1.000	104129	1.000	104129	1.000	104129	1.000	104129
106	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
107	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
108	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
109	1.000	5374	1.000	5374	1.000	5374	1.000	5374	1.000	5374	1.000	5374
110	1.000	165630	1.000	165630	1.000	165630	1.000	165630	1.000	165630	1.000	165630

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
111	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
112	1.000	14570	1.000	14570	1.000	14570	1.000	14570	1.000	14570	1.000	14570
113	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
114	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
115	1.000	14542	1.000	14542	1.000	14542	1.000	14542	1.000	14542	1.000	14542
116	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
117	1.000	38405	1.000	38405	1.000	38404	1.000	38405	1.000	38405	1.000	38404
118	1.000	14681	1.000	14681	1.000	14681	1.000	14681	1.000	14681	1.000	14681
119	1.000	22748	1.000	22748	1.000	22748	1.000	22748	1.000	22748	1.000	22748
120	1.000	30442	1.000	30442	1.000	30441	1.000	30442	1.000	30442	1.000	30442
121	1.000	1464	1.000	1464	1.000	1464	1.000	1464	1.000	1464	1.000	1464
122	1.000	4498	1.000	4498	1.000	4498	1.000	4498	1.000	4498	1.000	4498
123	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
124	1.000	124857	1.000	124857	1.000	124857	1.000	124857	1.000	124857	1.000	124857
125	1.000	507220	1.000	507220	1.000	507220	1.000	507220	1.000	507220	1.000	507220
126	1.000	68873	1.000	68873	1.000	68873	1.000	68873	1.000	68873	1.000	68873
127	1.000	211359	1.000	211359	1.000	211359	1.000	211359	1.000	211359	1.000	211359
128	1.000	25669	1.000	25669	1.000	25669	1.000	25669	1.000	25669	1.000	25669
129	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
130	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
131	0.019	123	0.979	6188	1.000	6322	0.088	554	0.996	6300	1.000	6322
132	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
133	1.000	20094	1.000	20094	1.000	20094	1.000	20094	1.000	20094	1.000	20094
134	1.000	5875	1.000	5875	1.000	5875	1.000	5875	1.000	5875	1.000	5875
135	1.000	84007	1.000	84007	1.000	84007	1.000	84007	1.000	84008	1.000	84008
136	1.000	137726	1.000	137726	1.000	137726	1.000	137726	1.000	137726	1.000	137726
137	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
138	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
139	1.000	51660	1.000	51660	1.000	51660	1.000	51660	1.000	51660	1.000	51660
140	1.000	38404	1.000	38404	1.000	38404	1.000	38404	1.000	38404	1.000	38404
141	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
142	1.000	174382	1.000	174381	1.000	174381	1.000	174382	1.000	174382	1.000	174381
143	0.998	19848	1.000	19891	1.000	19891	1.000	19883	1.000	19891	1.000	19891
144	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
145	0.999	8137	1.000	8143	1.000	8143	1.000	8142	1.000	8143	1.000	8143
146	0.152	940	0.830	5148	0.977	6056	0.336	2084	0.934	5789	0.991	6147
147	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
148	1.000	11830	1.000	11830	1.000	11830	1.000	11830	1.000	11830	1.000	11830
149	0.000	0	0.000	0	0.000	0	0.007	86	0.998	12665	1.000	12686
150	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
151	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
152	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
153	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
154	1.000	64526	1.000	64526	1.000	64526	1.000	64526	1.000	64526	1.000	64526

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
155	1.000	17901	1.000	17901	1.000	17902	1.000	17901	1.000	17902	1.000	17902
156	1.000	5181	1.000	5181	1.000	5181	1.000	5181	1.000	5181	1.000	5181
157	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
158	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
159	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
160	0.862	13574	0.997	15687	1.000	15734	0.958	15075	0.999	15726	1.000	15738
161	1.000	25229	1.000	25229	1.000	25229	1.000	25229	1.000	25229	1.000	25229
162	1.000	56887	1.000	56887	1.000	56887	1.000	56887	1.000	56887	1.000	56887
163	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
164	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
165	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
166	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
167	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
168	1.000	10244	1.000	10244	1.000	10243	1.000	10244	1.000	10244	1.000	10243
169	1.000	14180	1.000	14180	1.000	14180	1.000	14180	1.000	14180	1.000	14180
170	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
171	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
172	1.000	4875	1.000	4875	1.000	4875	1.000	4875	1.000	4875	1.000	4875
173	1.000	11719	1.000	11719	1.000	11719	1.000	11719	1.000	11719	1.000	11719
174	1.000	24621	1.000	24621	1.000	24621	1.000	24621	1.000	24621	1.000	24621
175	1.000	159601	1.000	159601	1.000	159601	1.000	159601	1.000	159601	1.000	159601
176	1.000	176218	1.000	176218	1.000	176218	1.000	176218	1.000	176218	1.000	176218

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
177	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
178	1.000	44606	1.000	44606	1.000	44606	1.000	44606	1.000	44606	1.000	44606
179	1.000	66112	1.000	66112	1.000	66112	1.000	66112	1.000	66112	1.000	66112
180	0.111	1098	1.000	9919	1.000	9919	0.429	4254	1.000	9919	1.000	9919
181	1.000	23943	1.000	23943	1.000	23943	1.000	23943	1.000	23943	1.000	23943
182	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
183	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
184	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
185	1.000	54119	1.000	54119	1.000	54119	1.000	54120	1.000	54120	1.000	54119
186	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
187	1.000	64214	1.000	64214	1.000	64214	1.000	64214	1.000	64214	1.000	64214
188	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
189	1.000	86071	1.000	86071	1.000	86071	1.000	86071	1.000	86071	1.000	86071
190	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
191	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
192	0.143	1968	0.982	13569	1.000	13805	0.398	5493	0.996	13757	1.000	13810
193	1.000	69921	1.000	69921	1.000	69921	1.000	69921	1.000	69921	1.000	69921
194	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
195	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
196	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
197	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
198	1.000	26487	1.000	26487	1.000	26487	1.000	26487	1.000	26487	1.000	26487

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
199	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
200	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
201	1.000	51683	1.000	51684	1.000	51684	1.000	51683	1.000	51684	1.000	51684
202	1.000	67864	1.000	67864	1.000	67864	1.000	67864	1.000	67864	1.000	67864
203	1.000	8544	1.000	8544	1.000	8544	1.000	8544	1.000	8544	1.000	8544
204	1.000	11209	1.000	11209	1.000	11210	1.000	11209	1.000	11209	1.000	11210
205	1.000	41498	1.000	41499	1.000	41499	1.000	41498	1.000	41499	1.000	41499
206	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
207	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
208	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
209	1.000	55416	1.000	55416	1.000	55416	1.000	55416	1.000	55416	1.000	55416
210	1.000	215283	1.000	215283	1.000	215283	1.000	215284	1.000	215283	1.000	215283
211	1.000	23287	1.000	23288	1.000	23288	1.000	23287	1.000	23288	1.000	23288
212	1.000	2350	1.000	2350	1.000	2350	1.000	2350	1.000	2350	1.000	2350
213	1.000	5176	1.000	5176	1.000	5176	1.000	5176	1.000	5176	1.000	5176
214	0.773	16571	1.000	21445	1.000	21445	0.963	20644	1.000	21445	1.000	21445
215	1.000	62510	1.000	62510	1.000	62510	1.000	62510	1.000	62510	1.000	62510
216	1.000	5954	1.000	5954	1.000	5954	1.000	5954	1.000	5954	1.000	5954
217	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
218	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
219	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
220	0.000	0	0.000	0	0.000	0	0.005	47	1.000	10239	1.000	10240

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
221	1.000	12411	1.000	12411	1.000	12411	1.000	12411	1.000	12411	1.000	12411
222	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
223	1.000	32698	1.000	32698	1.000	32698	1.000	32698	1.000	32698	1.000	32698
224	1.000	20338	1.000	20339	1.000	20339	1.000	20339	1.000	20339	1.000	20339
225	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
226	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
227	1.000	21267	1.000	21267	1.000	21267	1.000	21267	1.000	21267	1.000	21267
228	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
229	1.000	44744	1.000	44744	1.000	44744	1.000	44744	1.000	44744	1.000	44744
230	1.000	4225	1.000	4225	1.000	4225	1.000	4225	1.000	4225	1.000	4225
231	1.000	2164	1.000	2164	1.000	2164	1.000	2164	1.000	2164	1.000	2164
232	1.000	138524	1.000	138524	1.000	138524	1.000	138524	1.000	138524	1.000	138524
233	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
234	1.000	6750	1.000	6750	1.000	6750	1.000	6750	1.000	6750	1.000	6750
235	1.000	57397	1.000	57397	1.000	57397	1.000	57397	1.000	57397	1.000	57397
236	1.000	28725	1.000	28725	1.000	28725	1.000	28725	1.000	28725	1.000	28725
237	1.000	68220	1.000	68220	1.000	68220	1.000	68220	1.000	68220	1.000	68220
238	0.000	0	0.000	0	0.000	0	0.026	271	1.000	10412	1.000	10415
239	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
240	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
241	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
242	1.000	3264	1.000	3264	1.000	3264	1.000	3264	1.000	3264	1.000	3264

Table D.3.5: 5km Impactor’s tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
243	1.000	5150	1.000	5150	1.000	5150	1.000	5150	1.000	5150	1.000	5150
244	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
245	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
246	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
247	1.000	166835	1.000	166835	1.000	166835	1.000	166835	1.000	166835	1.000	166835
248	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
249	0.137	1970	0.932	13401	0.996	14314	0.309	4435	0.977	14043	0.999	14354
250	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
251	1.000	51559	1.000	51559	1.000	51559	1.000	51559	1.000	51559	1.000	51559
252	1.000	115758	1.000	115758	1.000	115758	1.000	115758	1.000	115758	1.000	115758
253	1.000	11402	1.000	11402	1.000	11402	1.000	11402	1.000	11402	1.000	11402
254	1.000	36174	1.000	36174	1.000	36174	1.000	36174	1.000	36174	1.000	36174
255	1.000	13631	1.000	13631	1.000	13631	1.000	13631	1.000	13631	1.000	13631
256	1.000	388434	1.000	388434	1.000	388434	1.000	388434	1.000	388434	1.000	388434
257	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
258	1.000	17276	1.000	17276	1.000	17276	1.000	17276	1.000	17276	1.000	17276
259	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
260	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
261	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
262	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
263	1.000	24749	1.000	24750	1.000	24750	1.000	24750	1.000	24750	1.000	24750
264	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
265	1.000	36883	1.000	36901	1.000	36901	1.000	36899	1.000	36901	1.000	36901
266	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
267	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
268	1.000	34969	1.000	34969	1.000	34969	1.000	34969	1.000	34969	1.000	34969
269	1.000	78219	1.000	78219	1.000	78219	1.000	78219	1.000	78219	1.000	78219
270	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
271	1.000	38316	1.000	38316	1.000	38316	1.000	38316	1.000	38316	1.000	38316
272	1.000	22685	1.000	22684	1.000	22684	1.000	22685	1.000	22685	1.000	22684
273	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
274	1.000	13282	1.000	13283	1.000	13283	1.000	13282	1.000	13283	1.000	13283
275	0.999	96520	1.000	96569	1.000	96569	1.000	96565	1.000	96569	1.000	96569
276	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
277	1.000	5137	1.000	5137	1.000	5137	1.000	5137	1.000	5137	1.000	5137
278	0.998	11238	1.000	11253	1.000	11255	1.000	11254	1.000	11257	1.000	11257
279	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
280	1.000	84636	1.000	84636	1.000	84636	1.000	84636	1.000	84636	1.000	84636
281	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
282	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
283	1.000	21331	1.000	21331	1.000	21331	1.000	21331	1.000	21331	1.000	21331
284	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
285	1.000	5154	1.000	5154	1.000	5154	1.000	5154	1.000	5154	1.000	5154
286	1.000	79579	1.000	79579	1.000	79579	1.000	79579	1.000	79579	1.000	79579

Table D.3.5: 5km Impactor's tsunami vulnerabilities and casualties, for all studied municipalities (continuation)

	Rumpf Rim-wave						Collins Rim-wave					
	best		expected		worst		best		expected		worst	
ID	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}	V_{tsu}	C_{tsu}
287	1.000	5623	1.000	5623	1.000	5623	1.000	5623	1.000	5623	1.000	5623
288	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
289	1.000	141603	1.000	141603	1.000	141603	1.000	141603	1.000	141603	1.000	141603
290	1.000	11078	1.000	11078	1.000	11078	1.000	11078	1.000	11078	1.000	11078
291	1.000	7401	1.000	7401	1.000	7401	1.000	7401	1.000	7401	1.000	7401
292	1.000	8877	1.000	8877	1.000	8877	1.000	8877	1.000	8877	1.000	8877
293	1.000	131737	1.000	131737	1.000	131737	1.000	131737	1.000	131737	1.000	131737
294	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
295	1.000	299937	1.000	299937	1.000	299937	1.000	299937	1.000	299937	1.000	299937
296	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
297	0.014	97	0.733	5076	0.989	6853	0.055	377	0.922	6388	0.997	6910
298	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
299	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
300	1.000	18887	1.000	18887	1.000	18887	1.000	18887	1.000	18887	1.000	18887
301	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
302	1.000	46864	1.000	46864	1.000	46864	1.000	46864	1.000	46864	1.000	46864
303	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
304	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
305	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
306	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
307	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
308	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0