EUROPEAN COMMISSION
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D.3 – Radiation protection and nuclear safety

Verification under the terms of Article 35 of the Euratom Treaty

Technical Report

SPAIN
Palomares

Environmental radioactivity monitoring arrangements
Monitoring of radioactivity in foodstuffs

18-20 June 2019

Reference: ES 19-01

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES	Environmental radioactivity monitoring in Palomares Foodstuffs radioactivity monitoring in Palomares
LOCATIONS	Palomares and Madrid, Spain
DATES	18-20 June 2019
REFERENCE	ES 19-01
TEAM MEMBERS	Mr V. Tanner (team leader) Ms L. Budinova
REPORT DATE	29 November 2019
SIGNATURES	

V. Tanner L. Budinova

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ABBREVIATIONS

CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
CSN	Consejo de Seguridad Nuclear
ENAC	Entidad Nacional de Acreditación
HPGe	High-purity Germanium
MAEC	Ministerio de Asuntos Exteriores, Unión Europea y Cooperación (Ministry of Foreign Affairs)
MITECO	Ministerio para la Transición Ecológica (Ministry for the Ecological Transition)
PVRA	Programa de Vigilancia Radiológica Ambiental (Palomares Environmental Radiological Surveillance Program)
RERA	Programa de Recuperación Radiológica Ambiental (CIEMAT Environmental Radiological Recovery Programme

TECHNICAL REPORT

1 INTRODUCTION

Under Article 35 of the Euratom Treaty, all Member States must establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with basic safety standards[1]. Article 35 also gives the European Commission the right of access to such facilities to verify their operation and efficiency. The radiation protection and nuclear safety unit of the European Commission's Directorate-General for Energy is responsible for undertaking these verifications. The Joint Research Centre Directorate-General provides technical support during the verification visits and in drawing up the reports.

The main purpose of the verifications under Article 35 of the Euratom Treaty is to provide an independent assessment of the efficiency and adequacy of monitoring facilities for

- liquid and airborne discharges of radioactivity from a site into the environment;
- levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant pathways;
- levels of environmental radioactivity on the territory of the Member State.

Taking into account previous bilateral protocols, a Commission Communication[2] describing practical arrangements for Article 35 verification visits in Member States was published in the *Official Journal of the European Union* on 4 July 2006.

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 PREAMBLE

The Commission notified Spain of its decision to conduct an Article 35 verification in a letter addressed to the Spain Permanent Representation to the European Union. The Consejo de Seguridad Nuclear (CSN) was subsequently designated as the contact point and coordinator for the preparations for the visit.

2.2 DOCUMENTS

To assist the verification team in its work, the national authorities supplied an information package in advance[3]. Additional documentation was provided during and after the visit. The information thus provided was used extensively in drawing up the descriptive sections of the report.

2.3 PROGRAMME OF THE VISIT

The Commission and the CSN discussed and agreed on a programme of verification activities in line with the Commission Communication of 4 July 2006.

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1 Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom (OJ L 13, 17.1.2014)

2 Commission Communication *Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty — Practical arrangements for the conduct of verification visits in Member States* (OJ C 155, 4.7.2006)

3 Replies to the preliminary information questionnaire addressed to the national competent authority, received on 3 June 2019

The opening meeting included presentations on the environmental and food radioactivity monitoring in Palomares. The verification team pointed to the quality and comprehensiveness of all the presentations and documentation.

The team carried out the verifications in accordance with the programme in Annex 1. It met the following representatives of the national authorities and other parties involved:

CSN

Ms. María Jesús MUÑOZ	Deputy Director for Environmental Radiological Protection
Ms. Carmen REY	Head of the Unit of Radioactivity Environmental Monitoring
Ms. Sofía LUQUE	Deputy Direction for Environmental Radiological Protection, Expert
Mr. Pablo MARTINEZ	Deputy Direction for Environmental Radiological Protection, Expert
Mr. Manuel APARICIO	International Department

CIEMAT

Ms. Yolanda BENITO	Head of the Department of the Environment (DMA)
Mr. Carlos SANCHO	Head of RERA
Ms. Mª Paz ANTÓN	Senior Researcher (RERA)
Mr. Antonio ARAGÓN	Senior Researcher (RERA)
Mr. Emanuel DELGADO	Technical assistance at Palomares

MAEC

Mr. Ignacio ATORRASAGASTI	Assistant Deputy Director for Industry, Energy, Transport, Communications and Environmental Affairs. State Secretariat for the European Union

SUBDELEGATION OF THE GOVERNMENT OF SPAIN IN ALMERÍA

Mr. Manuel DE LA FUENTE	Subdelegate of the Government of Spain in Almería

LOCAL AUTHORITIES

Mr. Antonio FERNÁNDEZ	Mayor of Cuevas del Almanzora
Ms. María Isabel ALARCÓN	Mayor of Palomares
Mr. Félix Mariano LÓPEZ	Mayor of Vera

3 BODIES HAVING COMPETENCE IN RADIOACTIVITY MONITORING

3.1 INTRODUCTION

Monitoring of the radiological situation in Palomares has been continuous since the accident. The responsible authority for the control and supervision of the environmental monitoring program is CSN and CIEMAT is responsible for its management. Monitoring is paid by the Spanish government – after 2010 there has been no US funding for the programme. No other organisations are involved in the monitoring.

3.2 CONSEJO DE SEGURIDAD NUCLEAR

The Consejo de Seguridad Nuclear (CSN), established in 1980, is the Spanish organisation competent in nuclear safety and radiological protection. It is independent from Government and reports to the Parliament of Spain.

CSN maintains a strict control and monitoring programme for nuclear installations and facilities related to medical, industrial or research activities, which are using radioactive substances, as well as for radioactively contaminated areas in Spain.

With respect to the environment, the CSN has the following regulatory functions:

- To assess the radiological impact of nuclear and radioactive installations on the environment, especially concerning radioactive discharges (aerial/liquid) into the environment, their accumulation in the surroundings of such installations and the evaluation of the resulting radiological impact.
- To run its own programmes of environmental radiological monitoring (both around nuclear installations and at national level) and to supervise all environmental radiological protection activities conducted by nuclear installations and by facilities using radioactive substances.

CSN is also responsible for proposing regulations to the Ministry for the Ecological Transition (MITECO) concerning radiological protection of workers and members of the public and safety criteria for waste management.

CSN also promotes research programmes in matters related to its competencies. It proposes regulations and informs the public through direct contact with the media, diffusion of publications and internet web page and an information centre.

3.3 CENTRO DE INVESTIGACIONES ENERGÉTICAS, MEDIOAMBIENTALES Y TECNOLÓGICAS

Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), former Junta de Energía Nuclear (JEN), which the Spanish Atomic Energy Commission founded in 1951, is a public research organization assigned to the Ministry of Science, Innovation and Universities under the General Secretariat for Scientific Policy Coordination. It is a public centre for research in the fields of energy, environment and technology.

CIEMAT is responsible for the Energy and Environment Research Plan in matters of radiological monitoring of soils affected by residual contamination in Palomares. In addition to managing the regular environmental monitoring programme, CIEMAT has also carried out several research projects on the Palomares situation and developed techniques for the final remediation.

4 CURRENT STATUS OF THE PALOMARES ACCIDENT SITE

4.1 SITE DESCRIPTION

On 17 January 1966 two aircrafts of the United States Air Force (a B-52G bomber and a KC-135 tanker airplane) collided during a refueling process of the bomber at 9,450 meters above ground over the village of Palomares in the municipality of Cuevas del Almanzora (province of Almería in Andalucía). As a result of this accident the four nuclear bombs (Mk28 type hydrogen bombs) being transported by the bomber were dropped. The conventional explosives of two bombs detonated and plutonium (Pu) was dispersed over an area of approximately 2.3 km^2. Two other bombs were recovered intact. A fraction of the disseminated $^{239+240}Pu$ was removed from the contaminated area in the remediation program applied immediately after the accident, but a significant contamination remains on the soil.

The radiologically contaminated area at Palomares is located in the northeast of the province of Almería, near the Quitapellejos beach and the Almanzora river mouth. It covers an area of over 200 hectares located in the SE of the Iberian Peninsula, near the Mediterranean coast. Contaminated areas fall within the municipalities of Cuevas del Almanzora and Vera.

The local environment is semi-desertic with dry riverbeds and few trees. The natural vegetation is semitropical with date palms, century plants, agaves, holm oaks, esparto grass (*Stipa tenacisima*), a wild variety or "acebuche" (*Olea europaea*), "rascamoños" (*Salsola verticilata*), *Ziziphus lotus*, *Asparragus albus*, etc. The area is characterized by a subtropical mediterranean climate with arid or semi-arid features, with a mean temperature between 16 and 20 °C. An average annual rainfall (about 200 l/m^2) is irregularly distributed throughout the year. Precipitations are sometimes especially abundant, causing flooding events in the area.

The terrain consists of vast plains that extend to the sea, especially in the Almanzora river mouth, while its western part composes relieves approximately 70 m high, qualifying as hillocks, formed mainly by clayey silt loam with frequent interbedded conglomerates, sandstones and fibrous gypsum. In general, the ground is hard, rocky and dry, coexisting porphyry and volcanic lamproitic rocks. The most abundant minerals are chlorite, muscovite illite, quartz, calcite and dolomite.

The main economic activities in the area are intensive agriculture (open pit farming and greenhouses) and tourism.

4.2 RADIOLOGICAL STATUS

Despite the extensive clean-up after the accident, significant plutonium contamination remains in the soil and no further remediation of the area has been undertaken. Currently there are four zones (total surface 40 ha) affected by residual contamination at different levels. These areas are distributed in several municipalities as follows:

- Zone 2: Fenced area in Puerto Blanco (municipalities of Vera and Cuevas del Almanzora).
- Zone 2-bis: Fenced area in the municipality of Cuevas del Almanzora, northeast of zone 2 and its adjacent plots, plus a plot located at the north of the road that leads to the Palomares cemetery.
- Zone 3: Fenced parcel in "Paraje de la Puntica", in the municipality of Cuevas del Almanzora, and the lands adjacent to the north and south of zone 3.
- Zone 6: Fenced area in Sierra Almagrera, west of Villaricos town.

The radiological criteria established in 2003 contemplated two scenarios:

- Total restriction of land use for those activities that involve a residual dose levels equal to or greater than 5 mSv/y. The derived activity concentration in soil for 5 mSv/y is 25 Bq/g of ^{239}Pu.
- Partial restriction of land use for those activities that could cause a residual dose level between 1 and 5 mSv/y. The derived activity concentration in soil for 1 mSv/y is 5 Bq/g of ^{239}Pu.

According to these criteria, the map below (Fig. 1) shows the radiological data in the affected areas. Green indicates no restricted areas; yellow indicates partially restricted areas and red totally restricted areas. Fig. 1 below shows the restricted areas; Fig. 2 provides a landscape overview of the zone 2.

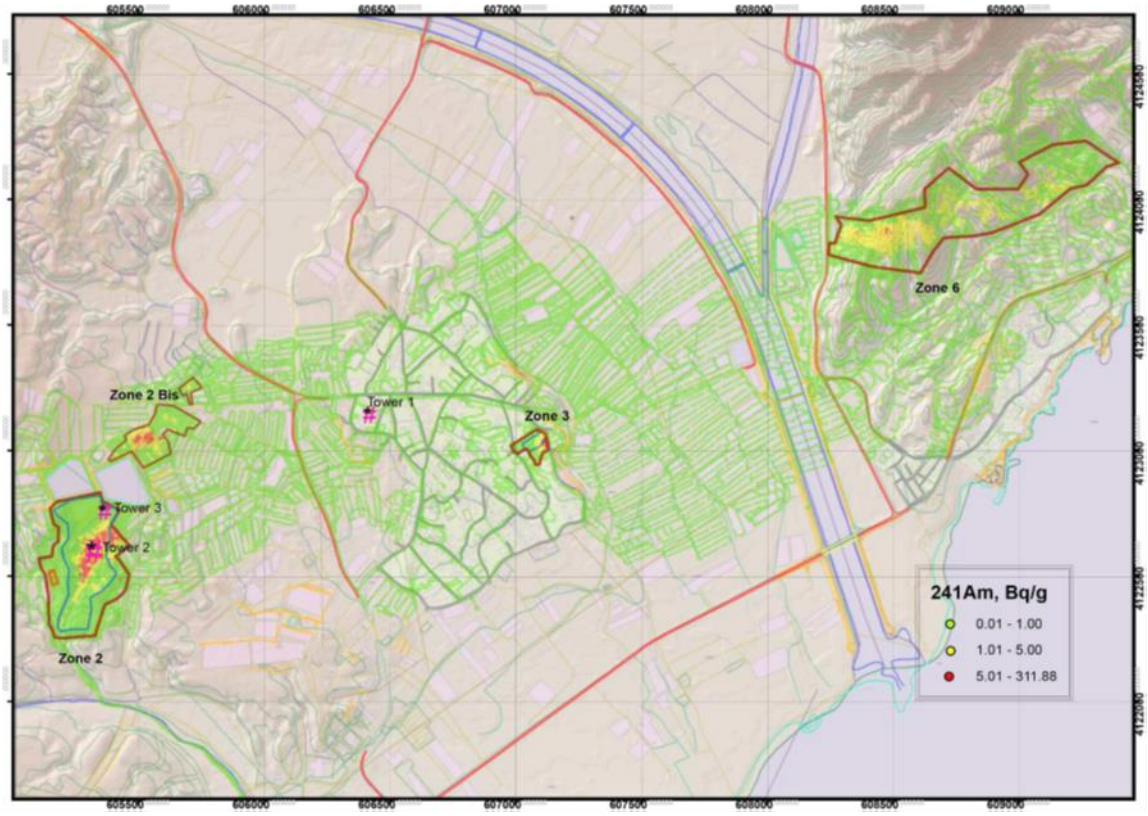

Figure 1. Contaminated areas in Palomares

Figure 2. Zone 2 landscape

4.3 CURRENT ACCESS RESTRICTIONS AND OTHER PROTECTIVE ACTIONS IN FORCE

Currently, except for RERA personnel classified as exposed category A workers, access is limited and is carried out accompanied by personnel designated by RERA, and under the radiological protection conditions indicated by RERA. When accessing fenced areas, the use of personal protective equipment and dosimeters is at the discretion of RERA, depending on the activity to be carried out. Although it is not a site with a conventional radiological classification, the general principles of radiological protection are applied. Thus, the time of permanence and the number of people who access will be, in any case, the minimum necessary.

Access to restricted areas includes transit spaces and marked passage areas, depos with the necessary equipment and systems for measuring external dose and surface contamination. These spaces are located inside the fence, next to the entrance doors. Access registration is filled in when entering the restricted areas. Figures 3 and 4 show the fence and the warning sign.

Figure 3. Zone 2 fence

Figure 4. Warning sign on the fence

4.4 REMEDIATION MEASURES

After the accident, the United States carried out clean-up operations in the contaminated areas using military personnel. Zone 6 was discovered later and has not been part of any clean-up operation. After the initial clean-up work, no further remediation actions have been undertaken, but the access restrictions and other protective actions are in force.

Currently, all planning for Palomares remediation has been halted, awaiting for completion of a binding remediation agreement with the United States.

5 RADIOACTIVITY MONITORING IN PALOMARES

5.1 INTRODUCTION

The current Palomares Environmental Radiological Surveillance Program (PVRA) is an evolution of the one initiated in June 1966, right after the accident, as a part of a scientific collaboration project named INDALO, carried out between USA and Spain. Afterwards, in 1986, CIEMAT was commended with the task of carrying out the technical performance of the program, and CSN with its supervision. Additionally, from 2007 to 2009, a detailed radiological three-dimensional study of the affected areas was carried out in order to know the extent of the remaining contamination. Based on the conclusions of this study, new criteria and requirements for the PVRA were established and the program was updated with a systematic pattern, which has been running from 2012 until now. This update includes the performance of a "Quality Control Program", carried out by a different department of CIEMAT among the 5-10% of the determinations of the PVRA, in order to assess the quality of the measurements.

The surveillance includes an extensive area beyond the "Zero Line" (230 ha considered in 1966 as contaminated because of the accident), with its center point located on the position 30N 607177.5 - 3123092, a radius of 2,600 m and an area of 21.23 km^2 (Fig. 5). The area is located within the Cuevas del Almanzora and Vera municipalities in the province of Almería.

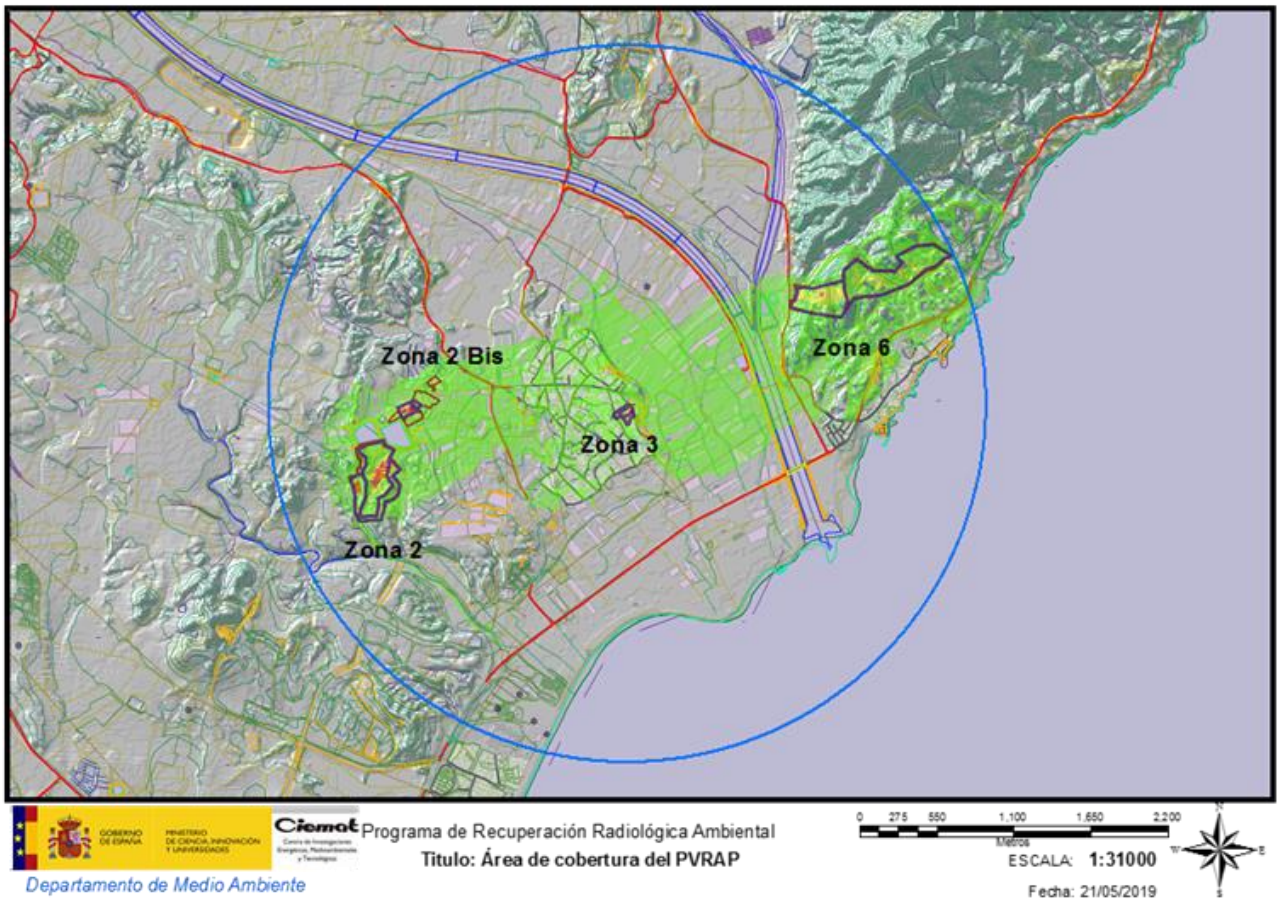

Figure 5. PVRA coverage

The PVRA is based on a surveillance network with 33 sampling stations; all of them except station 21 are placed outside the fenced areas (Fig. 6). Station 33 is a "blank station"; it is located outside the coverage area, close to the Mojacar town (Almería) in a zone with similar weather, orography and land use conditions to those within the PVRA area. The codes assigned to each sampling station and the general codes of type of sample usually collected in each station are shown in Tables I and II.

Table I. PVRA programme sample overview

TYPE OF SAMPLE	CODE 1		SUBTYPE OF SAMPLE	CODE 2
Bioindicators (fauna & flora)	OI	FL	Fennel (*Foeniculum vulgare*)	FOE
			Esparto (*Stipa sp, Lygeum Spartum*)	STI
			Thyme (*Themis spartum*)	THY
			Wild chard (*Beta vulgaris*)	BEV
			"Rascamoños" (*Launea arborescens*)	LAU
		FA	Land Gastropod (whole)	GTT
			Snail shell	GTC
			Snail body	GTB
Air	AIR		Dust particles (medium flux)	PPM
Deposition	DEP		Dry deposit	DES
	LLU		Rain water	LL2
	SS		Soil	S
Water	AGU		Drinking water	PO
			Surface water	SP
			Irrigation water	ABM
			Sea water	AM
Food	ALI	CAV	Rabbit meat	CC
		ML	Honey	ML
		L	Goat milk	LC
		P	Fish	PM
		C	Lettuce	LCH
			Pumpkin	CBZ
			Watermelon	SAN
			Pepper	PIM
			Cucumber	PEP
			Melon	MEL
			Zucchini	CIN
			Tomato	TOM
			Orange	NAR
			Lima beans	HAB
			Green peas	GUI
			Green beans	JUV
			Barley	CBD
			Olives	OLI
			Broccoli	BRE
Sediment	SD		Fluvial sediment	SDF
			Beach Sand	SDO

Table II. Codes and locations of the PVRA sampling stations.

SAMPLING STATION CODE	TYPE OF SAMPLE CODE
01	C
02	C
03	C
04	C
05	C
06	C
07	C
08	C
09	C
10	C
11	ML
12	C
13	C
14	C, S
15	C
16	OI/FA
17	C
18	OI/FL
19	ML
20	CAV
21	AIR, DEP/LLU
22	OI-FL, AIR, DEP/LLU, S
23	DEP/LLU, AGU, AIR, S
24	OI/FA
25	CAV
26	AGU, SD
27	AGU, SD
28	AGU
29	P
30	AGU, SD
31	L
32	OI/FL, S
33	OI/FL, C, S

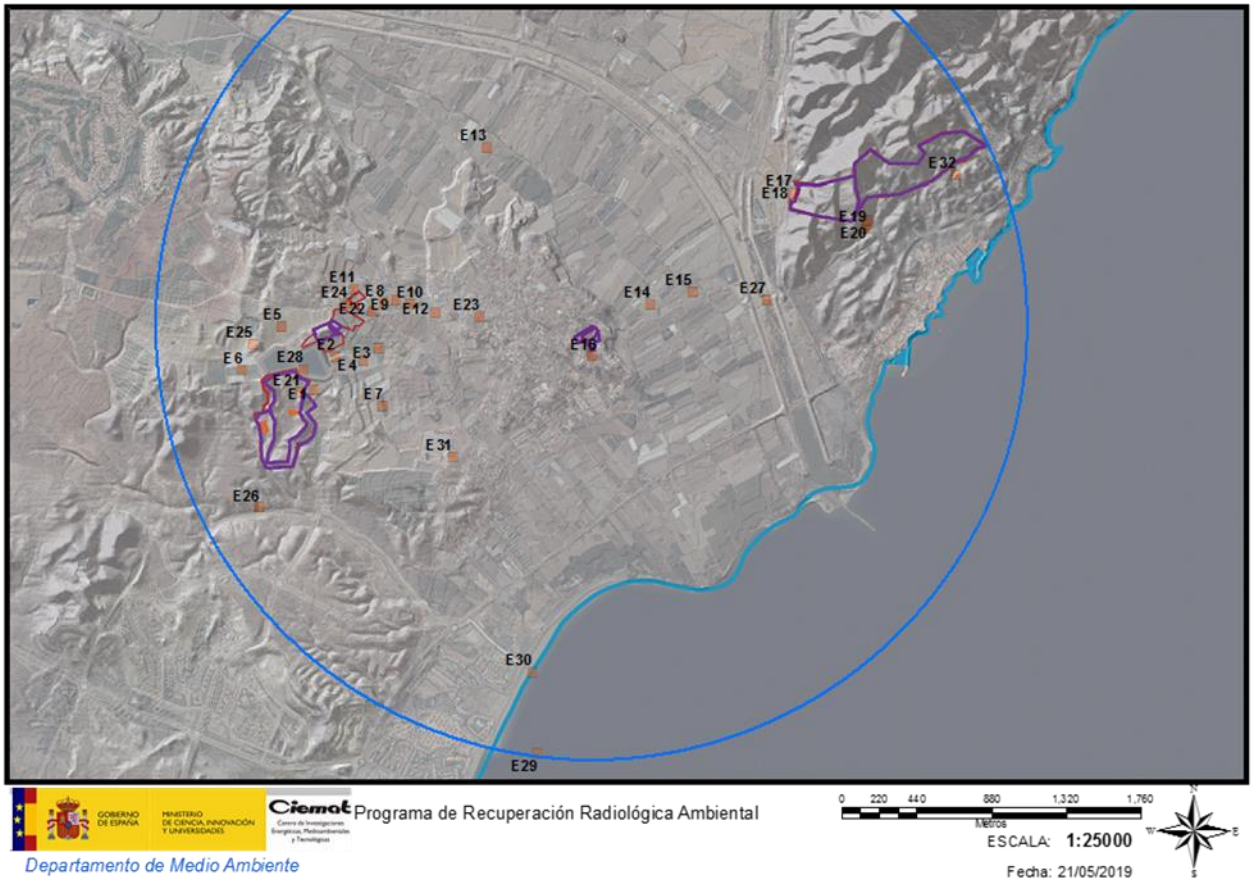

Figure 6. PVRA sampling locations

5.2 RADIATION DOSE AND DOSE RATE

The characteristics of the radionuclides that constitute the remaining source term in the area, and the determinations of the levels of gamma radiation made during the radiological characterization of the affected areas, show that the external irradiation does not constitute an appreciable radiological risk for the health of people or the environment. For this reason, it can be stated that the radiological risk caused by external radiation to workers and/or members of the public in Palomares is negligible. Consequently, gamma radiation measurements are not included in the PVRA.

However, there are national networks in place that include monitoring stations close to the Palomares site. The Directorate General for Civil Defense of the Ministry of Internal Affairs manages the Radioactivity Alert Network (RAR), which is a nationwide network with 903 automatic dose rate measurement stations, distributed throughout the national territory, provides continuous gamma dose rate measurements in real time. These data can be consulted at http://www.proteccioncivil.es/que-hacemos/rar/presentacion.

The stations near Palomares site are Águilas, Garrucha, Cuevas de Almanzora and Carboneras (Fig. 7). These stations are equipped with Geiger Müller detectors, which work in two different measurement ranges (high and low gamma dose rate), as well as a data transmission unit for a real time communication. The measurement capacity ranges from 10 nSv/h to 5 Sv/h.

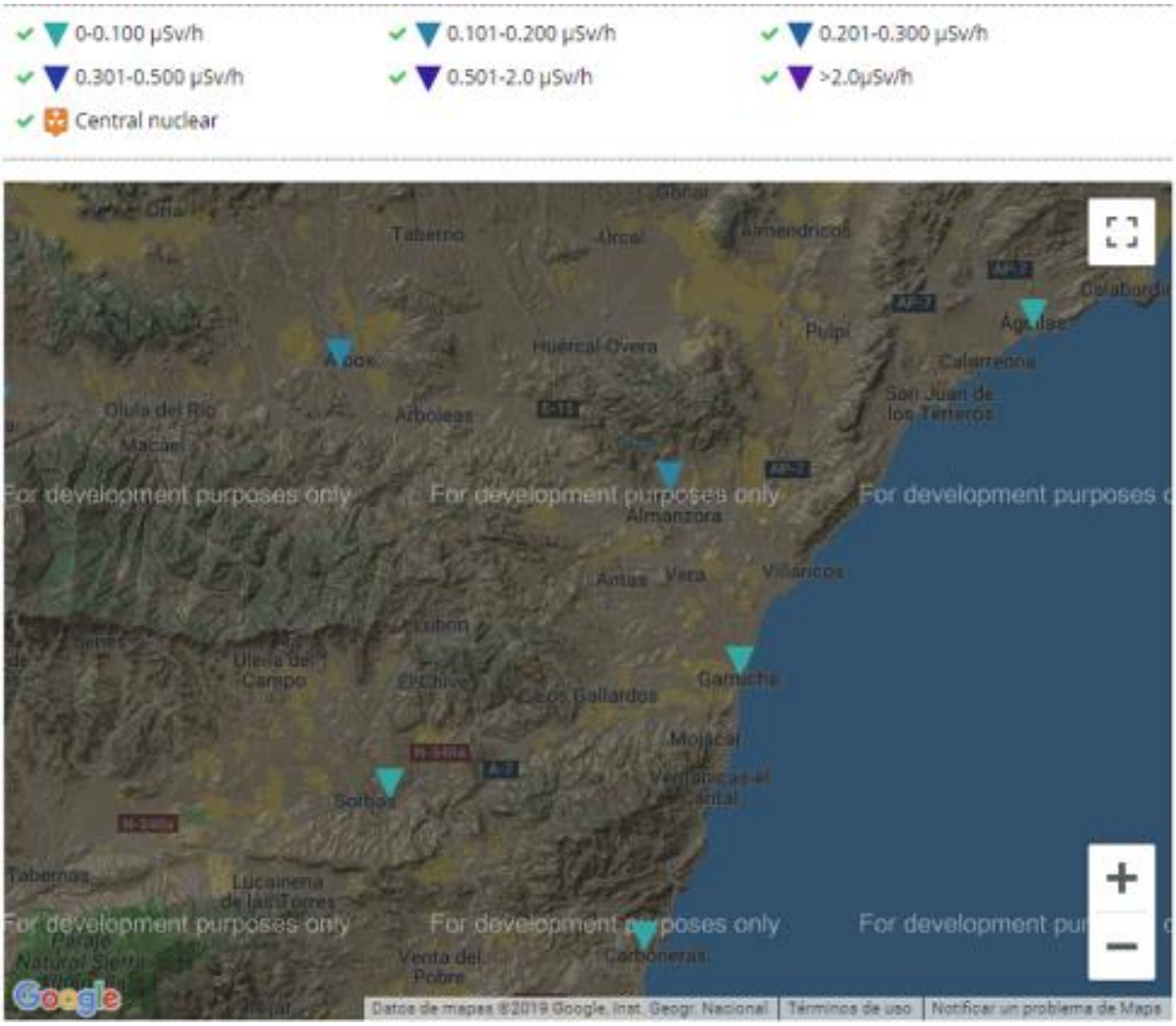

Figure 7. Radioactivity Alert Network (RAR telemetric network) near the Palomares site

5.3 RADIOACTIVITY CONCENTRATION IN AIR

There are three air sampling stations in the PVRA. Station E21 is located within the fenced zone 2, station E22 is located close to zone 2-bis; both of them sited in an area known as Puerto Blanco, and station E23 is placed in an urban location at the CIEMAT field laboratory in the Palomares town. The sampling stations located in both agricultural and urban areas of Palomares (Fig. 8) are provided with medium volume air samplers that allow the collection of airborne suspended particles.

The type of sampler used is a medium volume air-sampler TSP MFC (TE-BL series) (Fig. 10). This sampler is equipped with a 740 W motor allowing an airflow of 1.1-1.7 m^3/min, a mass flow controller to maintain a continuous flow, an elapsed time indicator that measures the operating time and a continuous flow recorder, which shows interruptions during operation, if any.

A working scheme is shown in Fig 9. Filters (glass microfiber filter EPM 2000 – 8x10 inch) containing retained particles are changed according to the technical procedure PT-RERA-23. Maintenance program includes weekly cleaning of the sampling device with a damp soft tissue, using water and ethanol, after removing the filter and a weekly visual check of electric cables and connections.

After collection, filters are folded three times to avoid breaking or losing of any particulate matter. ^{241}Am measurements are performed by gamma spectrometry, using an HPGe detector. $^{239+240}$Pu activity concentration is obtained by complete digestion of the filter using a mixture of strong acids followed by purification using ion-exchange resins and electroplating onto stainless steel discs for later quantification by alpha spectrometry.

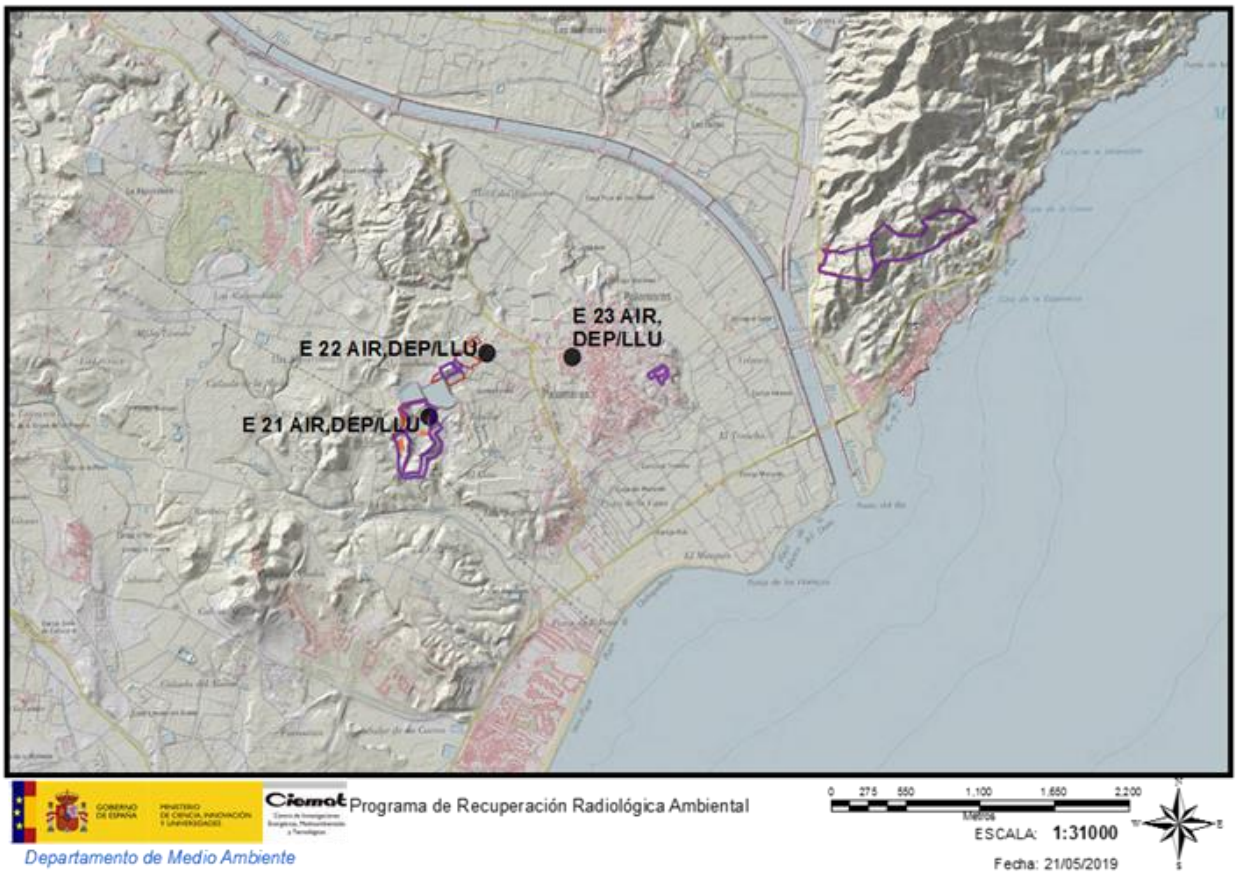

Figure 8. Location of air sampling stations in Palomares

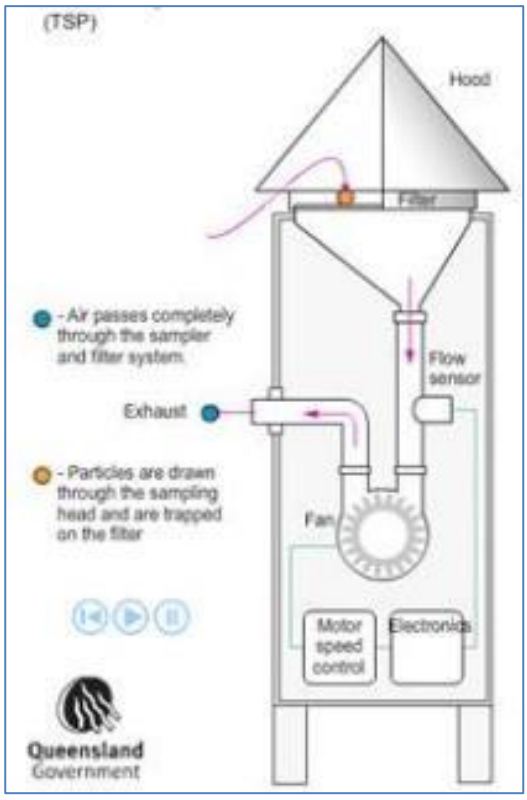

Figure 9. Working scheme of TSP MFC sampler

Figure 10. CIEMAT medium volume air sampler

5.4 ATMOSPHERIC DEPOSITION

In the PVRA, there are three dry/wet deposition monitoring stations (Table III). The location of the sampling stations is shown in Fig. 8. These stations are placed in the same locations as the air monitoring stations. They consist of a collecting surface (screened plastic funnel) and a 5-10 l plastic container. The funnel collecting surface is 0.058 m^2. It is covered with a grid to prevent the entry of insects, birds and leaves. The system is fixed to the ground with ropes and picks.

Table III. Monitoring of radioactivity in air (dry/wet deposition)

TYPE OF SAMPLE	LOCATION	SAMPLING STATION	FRECUENCY OF SAMPLING	NUMBER OF SAMPLES/YEAR
Dry/wet deposition	Zone 2	21	Monthly	12
	Close to Zone 2-bis	22	Monthly	12
	Plot in the urban area of Palomares where the CIEMAT office is located	23	Monthly	12
	TOTAL NUMBER OF SAMPLES			36

Samples are continuously taken during one month. When the sample is rain water (> 1,000 ml), water is transferred from the plastic container to a referenced plastic bottle, then the funnel is rinsed three times with distilled water and the sample is transported to the laboratory in Palomares. In the absence of precipitation (dry deposit < 1,000 ml), the plastic funnel is washed three times with deionized water (70-100 ml) lightly acidified and collected in the plastic container, then transferred to a plastic bottle and transported to the laboratory in Palomares. The technical procedure PT-RERA-27 establishes the performance of ^{241}Am determinations by gamma spectrometry and $^{239+240}$Pu by alpha spectrometry for each of the samples.

Figure 11. Atmospheric deposition collector

5.5 WATER

Monitoring of radioactivity in water is carried out by collecting samples for radiological analysis in the laboratory. Four types of water samples are collected in the PVRA: drinking water (tap water), fresh water from the two rivers Jatico and Almanzora within the coverage area, seawater from the nearby beach of Quitapellejos and irrigation water from the two main water ponds in Palomares (Fig. 12). Water samples are transported to the RERA laboratory in Madrid.

Additionally, the CEDEX takes seawater samples near the Palomares site as part of the national environmental radiological surveillance (REM) carried out under agreement with the CSN.

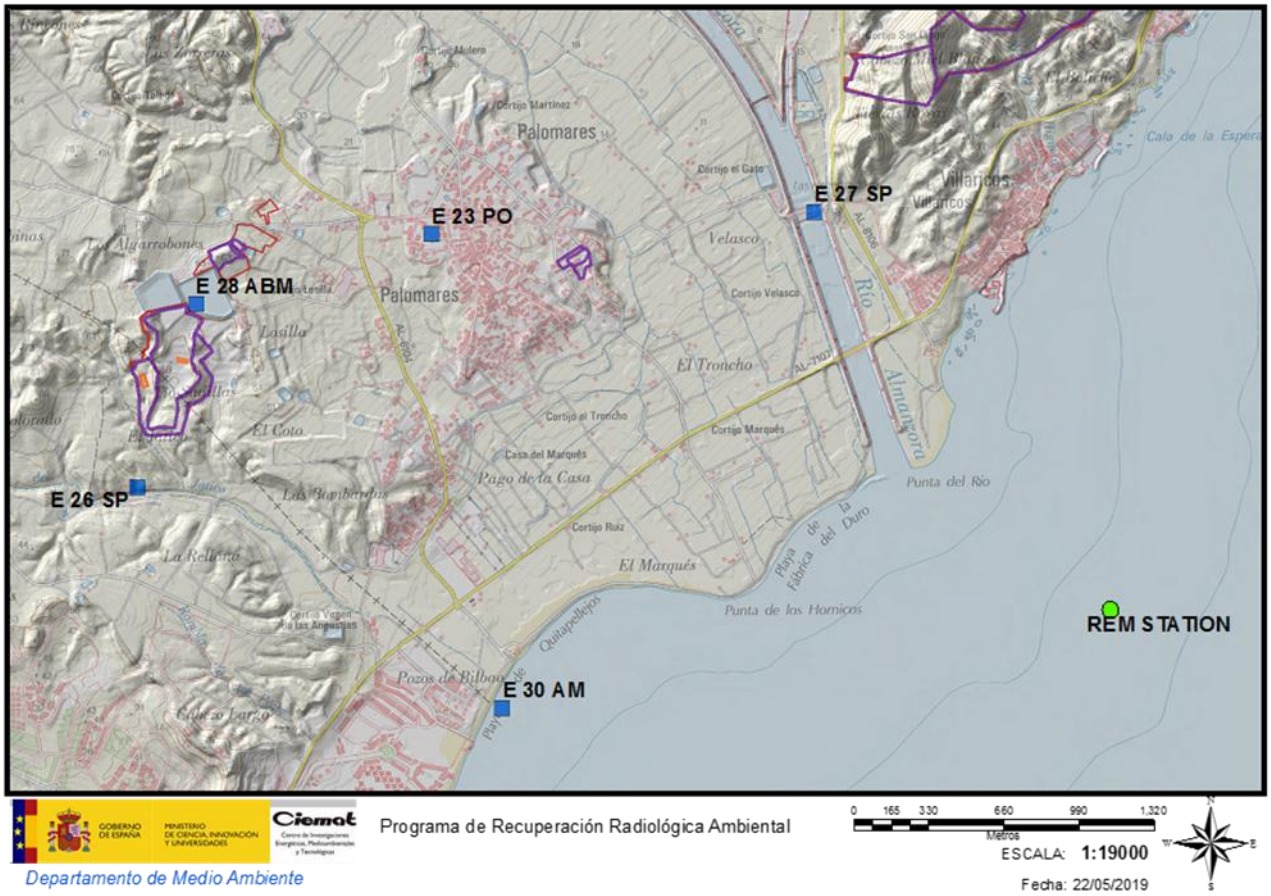

Figure 12. Water sampling locations in PVRA (blue) and REM (green)

5.5.1 Surface and marine waters

Table III below lists the surface and marine water samples taken for the PVRA. One-liter water samples are taken in plastic containers that are rinsed with the water to be sampled prior to filling. Depending on the expected period of conservation of the sample, prior to their treatment and measurement, water samples are kept in the dark and refrigerated between 1-5ºC, if the measurement is expected to be made within the first seven days after collection. If their treatment and measurement is expected to be delayed for over a week the water samples are acidified with nitric acid (pH <2) and kept in the dark and refrigerated between 1-5ºC.

One seawater sample is taken annually from the marine area off the coast of Palomares (Fig. 12). This sample is part of the CSN marine monitoring programme (REM). It was set in 2006 to control the radiological quality of waters near Palomares site. This sampling point is located in Garrucha[4].

Samples are taken in a quarterly basis. Gross alpha, gross beta, residual beta, gamma spectrometry, $^{239+240}$Pu, and ^{241}Am determinations are carried out. SASEMAR (Sociedad de Salvamento y Seguridad Marítima), a public company dependent from the Ministry of Public Works, collects seawater samples (10 liters) manually and sends them to the CEDEX laboratory for analysis together with a filled-in sampling sheet. Subsequently, CEDEX delivers a fraction of the sample (5 liters) to CIEMAT for the determination of ^{241}Am and $^{239+240}$Pu. The CEDEX laboratory is accredited by ENAC according to ISO 17025.

Table IV. Monitoring of radioactivity in surface and marine water (PVRA programme)

TYPE OF SAMPLE	LOCATION	SAMPLING STATION	FRECUENCY OF SAMPLING	NUMBER OF SAMPLES/YEAR
Sea water	Quitapellejos beach	30	Annual	1
River water	Almanzora river flow	26	Annual	1
	Jatico river flow	27	Annual	1
Irrigation water	Irrigation ponds near Zones 2,2-bis	28	Biannual	2
TOTAL NUMBER OF SAMPLES				5

5.5.2 Ground water and drinking water

Groundwater samples are not taken. Private groundwater wells in the area are not in use due to high salinity levels according to the geological and hydrogeological studies performed among 19 different sampling points. Most of these wells belong to private owners, who have confirmed that groundwater is not used for irrigation or human consumption.

Drinking water is obtained at station E23, from the tap located in the kitchen of CIEMAT´s field laboratory in Palomares. Samples are taken in plastic containers that are rinsed with the water to be sampled prior to filling. Depending on the expected period of conservation of the sample, prior to their treatment and measurement, water samples are kept in the dark and refrigerated between 1-5^{o} C if the measurement is expected to be made within the first seven days after collection. If their treatment and measurement is expected to be delayed for over a week, the sample is acidified with nitric acid (pH < 2) and kept in the dark and refrigerated between 1-5^{o}C. ^{241}Am is determined by gamma spectrometry and $^{239+240}$Pu by alpha spectrometry for each of the samples.

[4] (1º46'W, 37º14'N) (UTM X=609403.2, Y=4121469.8)

5.6 SOIL AND SEDIMENTS

Soil samples are collected in five stations, namely E14 (located in a cultivation plot on a flat area outside Palomares town), E22 (olive grove near the air monitoring device), E23 (non-cultivated land behind CIEMAT´s office within Palomares town), E32 (close to Villaricos cemetery, outside fenced zone 6 in Sierra Almagrera, in a slate zone) and E33 (non-cultivated area, dry clayey soil) (Fig. 13-14 / Table V).

Sediment samples are collected in three stations, two of them are located in dry river basins (E26 and E27) and the third one is taken at the seashore (E30) (Fig. 13 and 14 / Table V).

Table V. Monitoring of radioactivity in soil and sediments.

TYPE OF SAMPLE	LOCATION	SAMPLING STATION	FRECUENCY OF SAMPLING	NUMBER OF SAMPLES/YEAR
Soil	Cultivated plot next to the Almanzora river	14	Biannual	2
	Located at Puerto Blanco	22	Biannual	2
	Plot at the CIEMAT office	23	Biannual	2
	Zone 6 east	32	Biannual	2
	Next to Mojácar town. Control station	33	Biannual	2
Sediment	Jatico river	26	Annual	1
	Almanzora river	27	Annual	1
	Quitapellejos beach	30	Annual	1
TOTAL NUMBER OF SAMPLES				13

Surface soil samples (up to 5 cm depth) and sediments are collected from a 1 m^2 surface using a manual drill at five different points covering the mentioned sampling area. Five portions of soil/sediment are collected to compose the whole sample. Samples are sieved through a 2 mm screening net, and then transferred to a sealed plastic container. The collected samples are kept in a dry place at room temperature until its transportation to the laboratory. ^{241}Am determinations by gamma spectrometry and $^{239+240}Pu$ by alpha spectrometry are carried out for each sample.

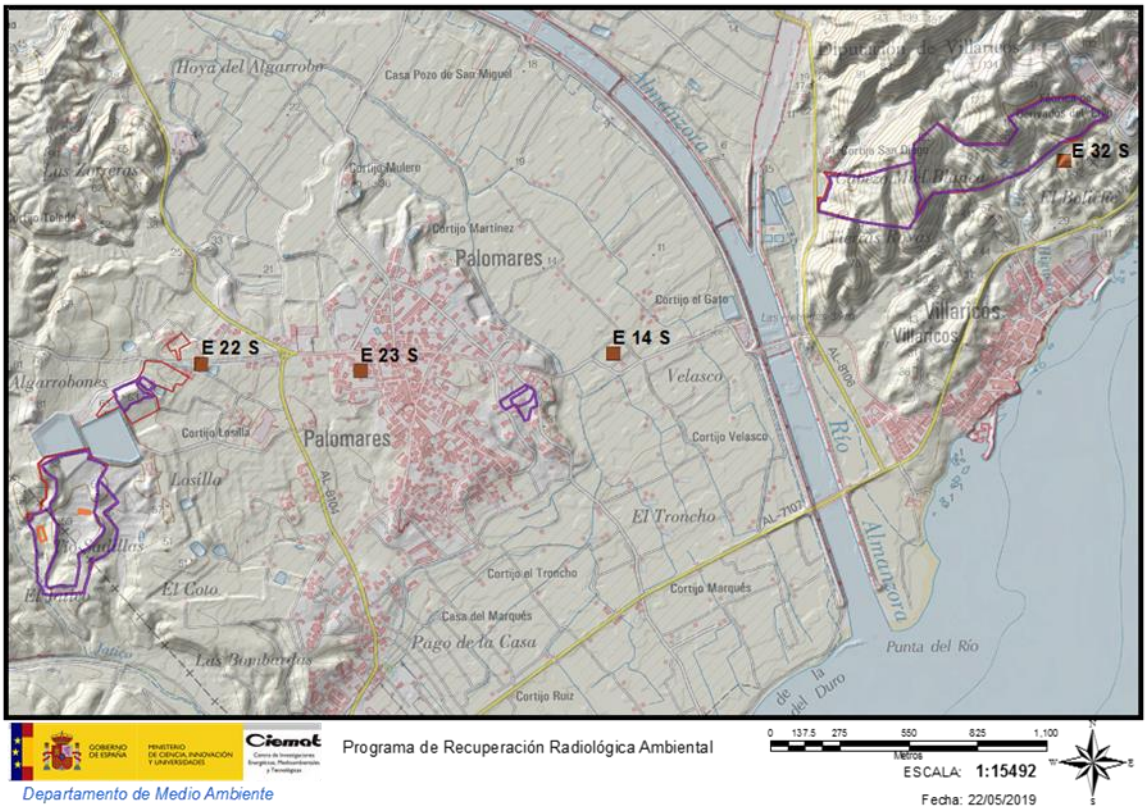

Figure 13. Soil sampling locations

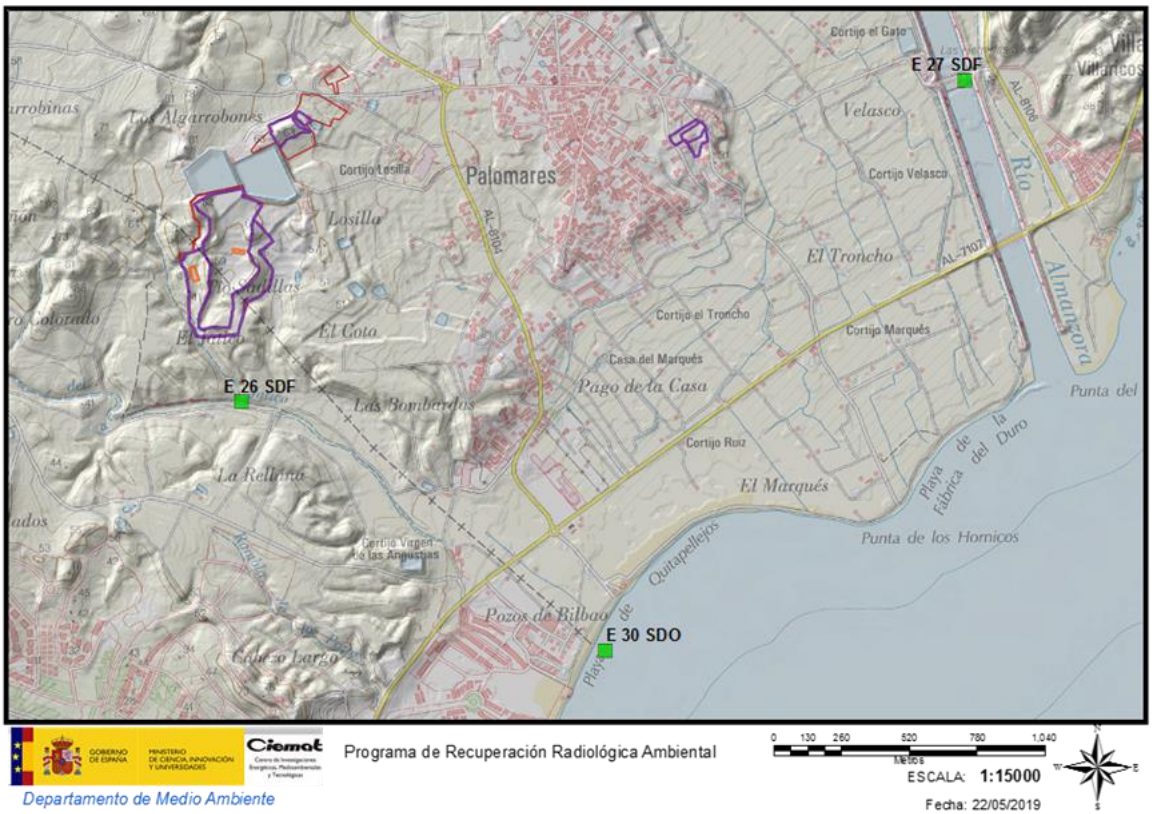

Figure 14. Sediment sampling locations

5.7 TERRESTRIAL BIOTA AND FLORA

As terrestrial biota, gastropods of the species *Otala Lactea* and *Octala punctata* are collected (Fig. 15 / Table VI). Terrestrial biota (snails) is collected in two stations: E16 is a non-cultivated plot, adjacent to Zone 3 within Palomares town; E24 is a cultivated land with olive trees in the surroundings of Zone 2-bis, in Puerto Blanco.

Flora is collected in four stations: E18 is between fenced Zone 6 and a greenhouse, E22 is located close to Zone 2-bis in the backyard of a house, E32 is a wild, non-cultivated zone close to Villaricos cemetery and fenced Zone 6 and E33 is close to Mojácar town, at the foot of a mountain. The autochthonous terrestrial flora collected includes mainly the following species: thyme (*Thymus Spartum*), esparto (*Stipa Spartum, Lygeum Spartum*), fennel (*Foeniculum vulgare*), "rascamoños" (*Launaea arborescens*), wild chard (*Beta vulgaris*).

Table VI. Monitoring of radioactivity in terrestrial biota and flora

TYPE OF SAMPLE	LOCATION	SAMPLING STATION	FRECUENCY OF SAMPLING	NUMBER OF SAMPLES/YEAR
Fauna	Close to Zone 3	16	Annual	1
	Close to Zone 2-bis	24	Annual	1
Flora	Close to Zone 6	18	Annual	1
	Close to Zone 2-bis	22	Annual	1
	Close to Zone 6 (east)	32	Annual	1
	Close to Mojácar. Control station	33	Annual	1
TOTAL NUMBER OF SAMPLES				6

The sampling procedures for the biota and flora are as follows:

- Biota: Snails are collected manually. Live snails are collected all over the station and placed into a mesh bag that is kept into an open plastic bottle to be transported to the laboratory in Palomares, where it is stored in a cool place until its transportation to the laboratories in Madrid.
- Flora: Collection of wild vegetation within each station is done randomly. A plot of 25 x 25 m is chosen to collect the sample that is composed by several specimens of a species. The aerial parts of the plant are preferable collected to assure the sample is composed by the part most recently grown. Samples are collected in plastic boxes and transported to the laboratory in Palomares. Samples are weighed and stored in the plastic boxes in a cool and dry place, until their transportation to the laboratories in Madrid. If needed, samples are kept refrigerated.

^{241}Am determination by gamma spectrometry and $^{239+240}$Pu by alpha spectrometry are carried out for each sample.

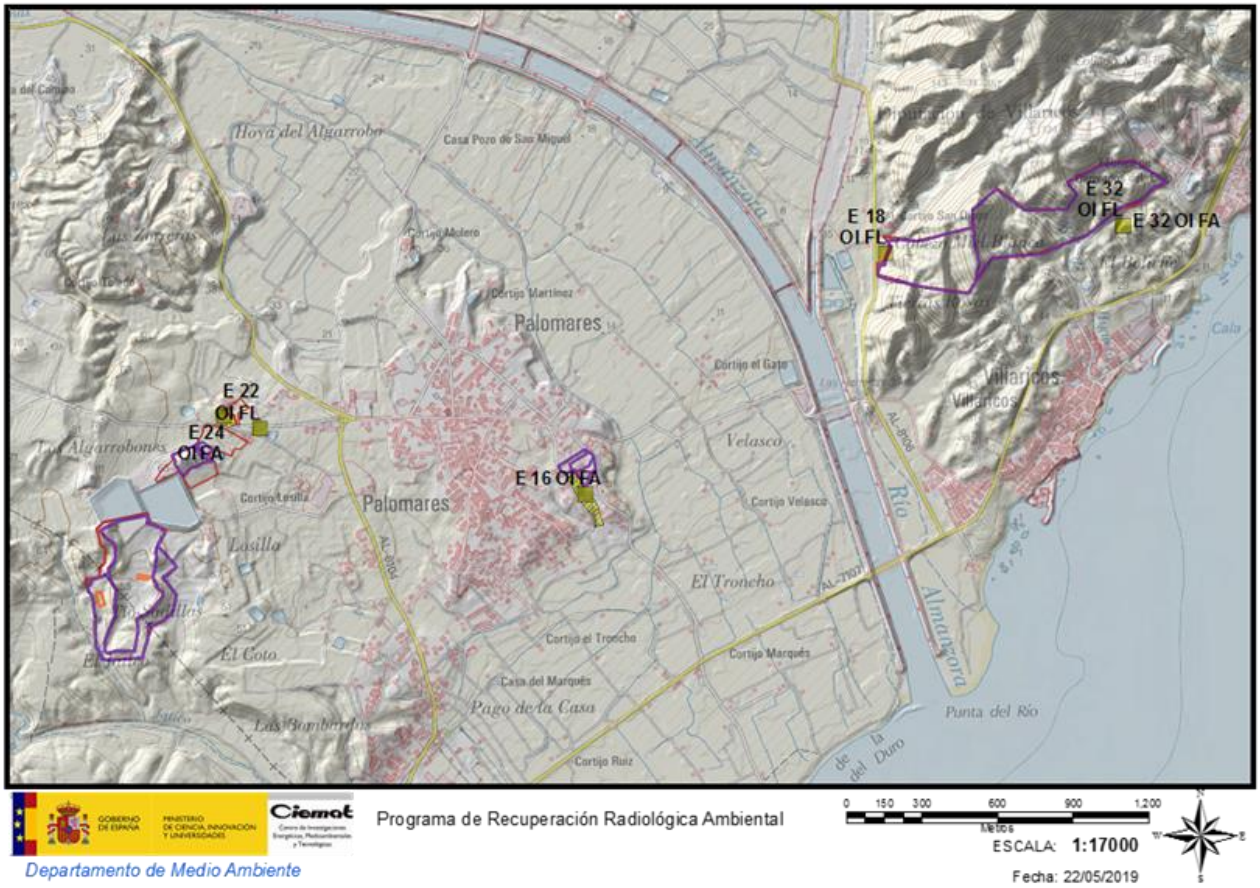

Figure 15. Biota and flora sampling locations

5.8 FOOD

5.8.1 Milk

Goat milk has been collected from a family farm located within the town of Palomares since June 2011. Samples are collected directly from the farm refrigeration tank (4 5ºC). A pitcher is used to transfer the milk from the tank to a graduated plastic bottle. Samples are stored in a refrigerator at 4ºC until they are transported in a portable cooler to the RERA laboratories in Madrid for later treatment and analysis. $^{239+240}$Pu and ^{241}Am are determined.

5.8.2 Foodstuffs

Foodstuffs are varied within the Radiological Surveillance Program. There are two main groups: cultivated vegetables (it should be remembered that in Palomares the main economic activity is intensive agriculture) and animal products such as milk, honey and fish. A map with the sampling stations where foodstuffs are collected is shown in Fig. 16.

Cultivated vegetables are collected in 16 stations in harvesting farms ran as a family business or by farming companies. Intensive agriculture is done both as open pit cultivation and in greenhouses. Currently, the main collected produce are lettuce, peppers, cucumbers, peas, lima beans, watermelon, tomatoes, zucchini, green beans, broccoli, oranges, olives, etc. The type of vegetable taken in each station might differ throughout the seasons, depending on the owner's cultivation choice.

Edible products of animal origin such as honey, goat milk and fish are collected nearby the Palomares site. Wild rabbit hunting is a recreational activity in the area; during the last years, there has been lack of availability of this kind of sample. An alternative is being sought through the hunting association of the area in order to guarantee the sample in the next campaigns.

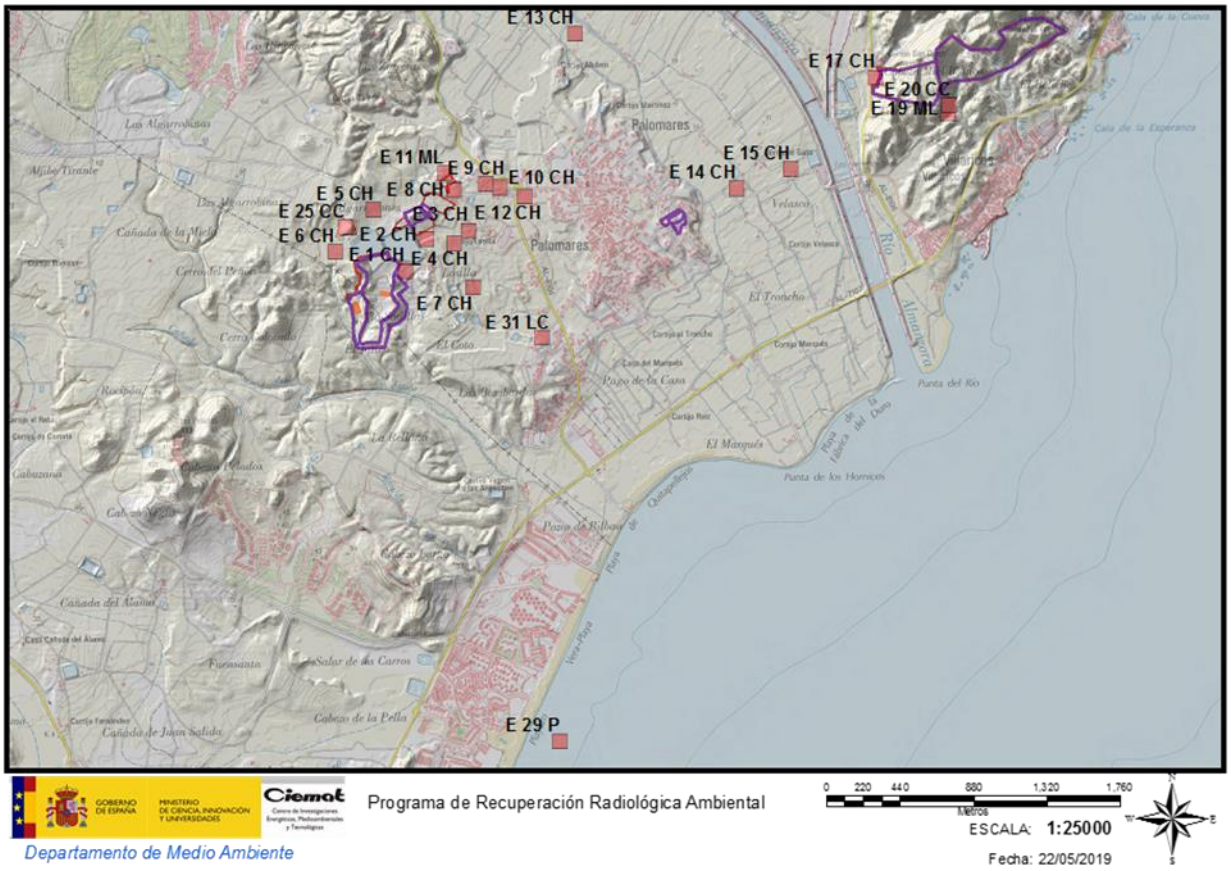

Figure 16. Food sampling locations

Table VII. Monitoring of radioactivity in food

TYPE OF SAMPLE	LOCATION	SAMPLING STATION	FRECUENCY OF SAMPLING	NUMBER OF SAMPLES/YEAR
Honey	Farm AL-195. Close to zone 2-bis	11	Annual	1
	Farm AL 344/AL 876. Close to zone 6	19	Annual	1
Goat milk	Farm 035AL354. Palomares town	31	Biannual	2
Fish	Continental shelf between Villaricos and Puerto Rey	29	Biannual	2
Rabbit meat	Close to the fences of the zones 2 and 6	20,25	Annual	2
Vegetables	Several sampling stations	01,02,04,05,06,09,12,13,14,33	Biannual	20
Oranges	Orange trees grove, SE zone 2	07	Annual	1
Lima beans	Several sampling stations	01,02,03,06	Annual	4
Green peas	Several sampling stations	01,02,03,06,15	Biannual	10
Green beans	Greenhouse close to zone 2-bis	08	Biannual	2
Celery	Several sampling stations	02,03	Biannual	4
Olives	Olive trees grove at the entrance roundabout in Palomares	10	Annual	1
Broccoli	Several sampling stations	01, 03,06,33	Biannual	8
			TOTAL NUMBER OF SAMPLES	**

**The total number of vegetable samples could vary from one campaign to another depending on the availability of the samples.

Vegetables (about 2 kg) are collected twice a year at their optimal harvesting time in sampling stations (25x25m^2) located both in greenhouses and in open pit cultivations. Vegetables are taken covering the whole sampling area; when grown as vertical crops (tomatoes, green peas, green beans) they are gathered along

the plant length. Vegetables are placed in plastic boxes to be transported and conditioned at the laboratories in Palomares, then taken to the RERA laboratories in Madrid (Fig. 17). The amount of sample collected varies depending on the vegetable, from 2 kg (i.e. lettuce) to 6 kg (i.e. zucchini, watermelon).

Figure 17. Food samples collected from Palomares

Honey (250 g) is collected in spring (when flowering conditions allow) by the bee farm owners and placed in plastic bottles.

Fish samples are obtained at the main fish wholesale market in Garrucha (Almería) by a fisherman that has been previously instructed about the area where the fish should be taken. These samples (average size 2-3 kg) are transported in portable coolers to the laboratory in Palomares where they are frozen until further treatment. $^{239+240}$Pu and ^{241}Am determinations are carried out on all food samples.

5.9 INFORMATION FOR THE GENERAL PUBLIC

CIEMAT carries out a communication with the local authorities about the activities performed in Palomares within the scope of the Environmental Surveillance Plan.

On the other hand, CIEMAT has participated in conferences, interviews and courses related to the situation of Palomares. It also participates in the parliamentary responses on this issue

The CSN issues annually a report for the Congress and the Senate about the main activities carried out by this organization regarding nuclear safety and radiation protection. This report includes information about the environmental radiological monitoring programs and networks, where a section dedicated to the Palomares monitoring can be found.

Additionally, in response to the request of the "Advisory Committee for Information and Public Participation" of the CSN, which is a Committee composed by more than 30 independent experts with the aim of enhancing transparency and public information, the CSN has issued a dedicated publication about the consequences of the Palomares accident called "*Palomares.En el camino de la normalización radiológica (1996/2013)*", in order to contribute to inform the public of this subject. This organization has also included information about Palomares in its website.

Finally, in compliance with the functions entrusted to the CSN relating public information, the regulatory body has developed a computer application to give the public access to the environmental radiological surveillance data in Spain (Fig. 18). The system can be accessed through the CSN website. After the application was launched in 2017, more information is continuously being made available as the data are

reviewed and some other pieces of information as, for example, the description and identification of the sampling stations, are completed, aiming at making it easy to understand for the public. In the case of the environment of the Palomares site, this data are the data corresponding to the coastal waters of the REM network (which can be consulted from 2008 to 2018) and the PVRA program (which can be consulted from 2012 to 2018),through the website https://www.csn.es/valores-radiologicos-ambientales-pvra-rem.

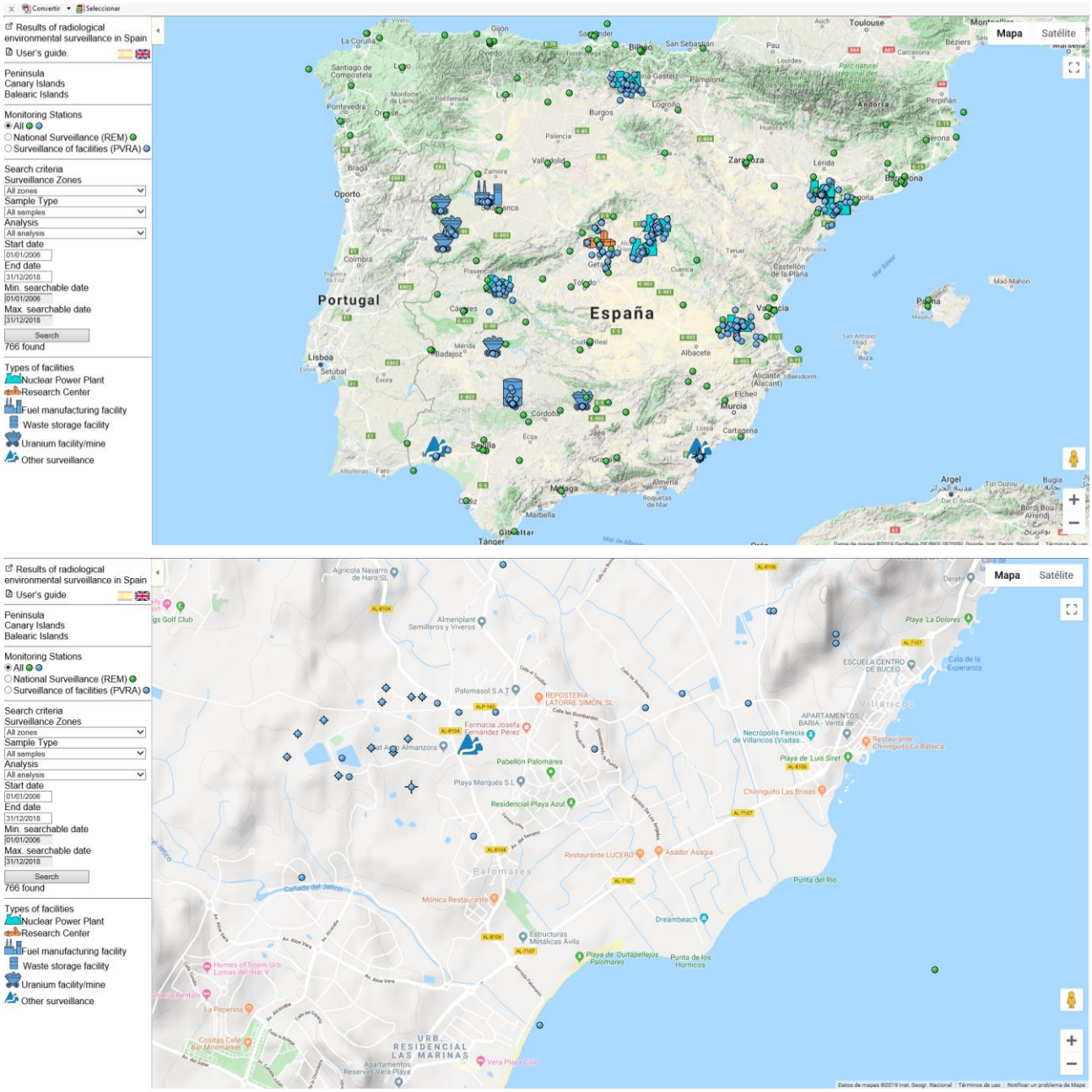

Figure 18. CSN website application for environmental radioactivity monitoring data

6 LABORATORIES PARTICIPATING IN THE MONITORING PROGRAMME

6.1 CIEMAT ENVIRONMENTAL RADIOLOGICAL RECOVERY PROGRAMME

6.1.1 Introduction

Since the accident, source term in Palomares contains plutonium isotopes, the analytical task of the environment monitoring is to measure low levels of plutonium in a wide variety of environmental samples. This is done either by $^{239+240}$Pu determination using alpha spectroscopy or by ^{241}Am (^{241}Pu decay product) determination using gamma spectroscopy. Gamma spectroscopy does not require radiochemical preparations, so it is the preferred method. Experimental studies have indicated that the activity ratio A($^{239+240}$Pu) / A(^{241}Am) = 4 is valid for the soil contamination in Palomares. This ratio, that has been proven to be statistically valid just for soil samples, allows to obtain an accurate and fast estimation of the ^{239}Pu concentration, based on the statistical studies developed.

CIEMAT Environmental Radiological Recovery Programme (RERA) is responsible for designing and executing the tasks performed within the PVRA. RERA is responsible for sampling, transport of the samples from Palomares to Madrid, reception and registry of the samples, treatment, analysis, sample preparation, measurement and evaluation of the data and reporting to the CSN.

RERA laboratories are not accredited. There is a small field laboratory in Palomares, but the majority of the analytical work is done in its well-equipped Madrid laboratories. At present, there is one person working in Palomares facilities and four people in Madrid laboratories. The full accomplishment of the activities within the Palomares monitoring programme requires 6-7 person years of work annually.

6.1.2 Air filters

Air filters are folded three times to avoid breaking and loss of any particulate matter. They are placed in zip lock plastic bags, referenced and transported to CIEMAT (Fig. 19), where Plutonium and Americium activities are determined.

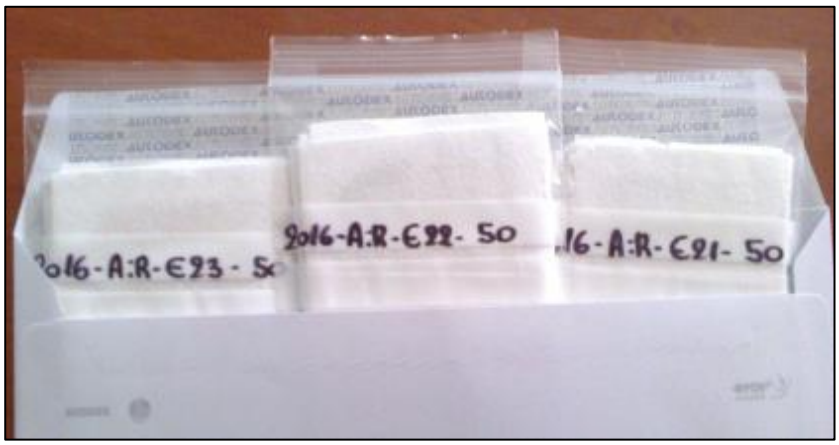

Figure 19. Air filters in zip lock plastic bags prepared for transportation

Filters are weighed using a thermobalance. Before weighing the filter containing the air particles, the humidity must be eliminated. Filters are dried in a stove at 60ºC, and then allowed to cool down within a desiccator. The zip lock plastic bag containing the filter is folded once and fastened with a paper clip, and then it is placed onto the gamma spectroscopy detector (Fig. 20).

Figure 20. Air filter ready for measurement by gamma spectrometry

Sample preparation for Plutonium determination includes three stages:

1. Sample preparation (ashing at 550^{o}C, filter and dust dissolution using strong acids). At this stage, radiochemical tracers are added to later quantify chemical recovery.
2. Radiochemical purification of Plutonium using ion exchange resins.
3. Preparation of the sample by electroplating the eluted solution obtained in the previous stage onto stainless steel discs.
4. Stainless steel discs are measured by alpha spectrometry to quantify plutonium using silicon barrier detectors.

6.1.3 Dry/wet deposition and water samples

These samples consist on aqueous solutions containing solid particles and dissolved material.

Sample preparation for gamma measurement

Liquids are treated to obtain a precipitate of $Fe(OH)_{3,}$ then filtered to separate the precipitate from the solution. The filter containing the precipitate is placed into a plastic container and measured with a HPGe detector to determine the ^{241}Am content in the sample.

Sample preparation for plutonium determination

After measurement by gamma spectrometry, the filters containing the precipitate are measured as described in 6.1.2.

6.1.4 Bioindicators and food samples

Food samples are measured ready for consumption: washed and chopped, then weighed, dried in a laboratory stove and finally ashed in a furnace oven at 550^{o}C. Ashes are weighed to estimate the fresh/dry weight factor.

Honey samples are dried in a stove, then ashed at 550^{o}C. Goat milk is also dried and ashed. Bioindicator samples follow the same treatment, however they are not washed. In the snail samples, the shell is separated from the soft tissues when considered a food source. Both parts are dried and then ashed as previously indicated. As bioindicators, gastropods are treated as a whole.

Sample preparation for gamma measurement

Ashes are placed into a plastic container and measured with an HPGe detector to determine the ^{241}Am content in the sample.

Sample preparation for plutonium determination

The procedure is divided into three stages:

1. Ashes dissolution using strong acids and addition of tracers.
2. Radiochemical purification of plutonium (by ionic exchange resins).
3. Preparation of the measurement sample by electroplating the eluted solution obtained in the previous stage.

6.1.5 Soil and sediment samples

Sample preparation for gamma measurement

Soil and sediment samples are dried at 60^{o}C until reaching constant weight, then measured with a HPGe detector to determine the ^{241}Am content in the sample.

Sample preparation for plutonium determination

The procedure is divided into four stages:

1. Drying and ashing of the samples.
2. Ashes digestion using a mixture of strong acids and addition of radiochemical tracers.
3. Radiochemical purification of Plutonium (by ion exchange resins).
4. Preparation of the measuring source by electroplating the eluted solution obtained in previous stage.

6.1.6 Equipment

The RERA laboratory has the following main equipment:

- EQ-RERA-167 extended range coaxial HPGe detector. The detector is connected to a preamplifier iPA model and a multichannel analyzer model Inspector 2000 (Canberra Inc.). Spectra are saved to the computer memory and analyzed with standard Canberra Genie 2000 software.
- EQ-RERA-76 system, which has two Low Energy HPGe detectors: 85528 detector is situated on the upper part of the metal frame and 87516 detector on lower part of the metal frame. Sample is placed between the detectors for maximum efficiency. The detector is connected to a preamplifier and a multichannel analyzer model Inspector 2000 (Canberra Inc.). Spectra are saved to the computer memory and analyzed with standard Canberra Genie 2000 software.
- EQ-RERA-27 Low Energy HPGe detector. The detector is protected by a Carbon Epoxy Shield. The detector is connected to a preamplifier and a multichannel analyzer model Inspector 2000 (Canberra Inc.). Spectra are saved to the computer memory and analyzed with standard Canberra Genie 2000 software.
- EQ-RERA-28 Low Energy HPGe detector. The detector is protected by a Carbon Epoxy Shield. The detector is connected to a preamplifier and a multichannel analyzer model Inspector 2000 (Canberra Inc.). Spectra are saved to the computer memory and analyzed with standard Canberra Genie 2000 software.
- EQ-RERA-87 model 576-WM ORTEC (MCB1) is an alpha spectroscopy workstation holding eight identical high-integrity modular sealed vacuum chambers with a manually controlled vent/hold/pump valve and an adjustable bias interlock that allows automatic bias application when the chamber is ready for sample counting and holds double cells containing 16 silicon barrier semiconductor alpha detectors model TR-21-300-100 with a nominal active area of 300 mm^2 and resolution of 21 keV. Each detector is assigned with 1000 channels, covering an energy range from 0 to 10 MeV.

- EQ-RERA-88 is a module model 576-WM ORTEC (MCB2) is an alpha spectroscopy workstation holding eight identical high-integrity modular sealed vacuum chambers with a manually controlled vent/hold/pump valve and an adjustable bias interlock that allows automatic bias application when the chamber is ready for sample counting and holds double cells containing 16 silicon barrier semiconductor alpha detectors mod TR-21-300-100 with a nominal active area of 300 mm^2 and resolution of 21 keV. Each detector is assigned with 1000 channels, covering an energy range from 0 to 10 MeV.
- EQ-RERA-89 is an alpha spectroscopy workstation (OCTETE PLUS) containing eight identical high-integrity modular sealed vacuum chambers with a manually controlled vent/hold/pump valve and an adjustable bias interlock that allows automatic bias application when the chamber is ready for sample counting. The workstation holds eight ion-implanted silicon charged-particle alpha detectors with a nominal active area of 300 mm^2 and resolution ≤ 20 keV. Each detector is assigned with 1000 channels, covering an energy range from 0 to 10 MeV.

Laboratory building is provided with continuous ventilation; air-conditioned rooms are maintained at a constant temperature of 21˚C. Electricity is obtained from a set of storage batteries (UPS) to avoid anomalies caused by transient supply cuts.

6.1.7 Management of results and samples

Measurement result files are stored on computer; file folders are kept with the spectra from the measuring equipment and spreadsheets are completed with the results obtained. These files are currently in a partition of a CIEMAT server where the so-called corporate disks are located. The Information Technologies Division makes periodic backups of these corporate discs.

Detection limits are computed by using ISO 11929:2010 criteria "*Determination of the characteristic limits (decision limit and limits of the confidence interval) for measurements of ionizing radiation - Fundamentals and application*".

Reports submitted to the CSN are in a paper format, also available as PDF files. There are databases where the information related to the sample collection and measurement is saved, as well as spreadsheets where data extracted from the database are processed for inclusion in reports. The annual radiological surveillance data has been sent to CSN in the Keeper format since 2011.

The latest reviews of the Palomares radiological surveillance results record can be found in the documents DT-RERA-45, DT-RERA-52 and DT-RERA-61.

When the measurements are completed, samples are stored in stackable plastic boxes for five years (Fig. 21). Sample management is done following Directive 91/689/CEE and Order MEM 304/2002. If the samples to be withdrawn are classified as toxic or dangerous, their disposal will follow CIEMAT´s dangerous waste disposal procedure. If not, their final disposal will be carried out as conventional waste according to the type of material to be eliminated (organic, plastic, paper, glass and metal).

Figure 21. Palomares sample archive box

6.2 CIEMAT Environmental Radioactivity Unit and Radiological Surveillance

6.2.1 Introduction

The CIEMAT Environmental Radioactivity Unit and Radiological Surveillance (URA y VR) is in charge of performing the quality control analyses in 5-10 % of the different samples collected within the monitoring program. RERA provides the samples to measure ^{241}Am by gamma spectrometry to URA y VR. When RERA resumes radiochemical analyses, also plutonium (and alpha spectrometry) determinations will undergo quality control assessments.

The gamma spectrometry laboratory is accredited by ENAC according to the ISO 17025. The laboratory participates annually in different intercomparison exercises with different types of matrixes. The alpha spectrometry laboratory is accredited by ENAC for the determination of ^{239,240}Pu, ^{238}Pu and ^{241}Am in environmental samples.

6.2.2 Equipment

Gamma spectrometry laboratory

URA y VR laboratory 3, gamma spectrometry laboratory, has nine HPGe detectors (one standard coaxial, two broad energy coaxial, three extended range coaxial and three reverse electrode coaxial), with relative efficiencies of 25.0 % to 115.7 %. HPGe detector resolution ranges from 1.72 keV to 2.05 keV for the ^{60}Co peak at 1.33 MeV. The detectors are protected either by 150 mm iron shielding or lead shielding lined with copper or tin to absorb the fluorescent X-rays emitted by the lead. The aforementioned shields also effectively block natural terrestrial radiation. The detectors are connected to five racks containing HV power supply units, spectroscopy amplifiers and Canberra ADCs. Spectra are saved to the computer memory with five Canberra Acquisition Interface Modules (AIMs) and analyzed with standard Canberra Genie 2000 software. The detectors are located in a continuously ventilated, air-conditioned room at a constant temperature of 21˚C. Laboratory radon concentration ranges from 5 Bq/m^3 to 134 Bq/m^3 with a mean value

of 35 Bq/m^3. Background levels of all detectors are measured every 6 months with a counting time of 600,000 s.

In the case of the Palomares samples, ^{241}Am is determined. Samples are measured during 80,000 s to achieve the required limit of detection.

High purity germanium detectors are calibrated with different experimental calibration sources in the range between 59 keV to 1838 keV. Efficiency and energy calibration of the detectors is performed monthly with calibration sources. The energy calibration is checked for each sample by verifying the natural gamma-peaks at 351 keV, 5511 keV, 609 keV and 1460 keV. All detection limits are computed by Canberra Genie 2000.

Alpha spectrometry laboratory

The alpha spectrometry system has 12 PIPS detectors. The detectors are calibrated in energy and efficiency by means of a Calibration Standard Source (NºSERIE: 090-96/MR96N020) prepared by Metrology Department of CIEMAT, with an alpha activity of 113.3 ± 0,5 (0,4%)Bq, electroplated in a steel disk of 2" diameter. Calibration procedures are described in the standard methodology RA/PT-L401. The preparation of tracers for analysis of plutonium (^{242}Pu) and americium (^{243}Am) are described in RA/PT-L410. These standards are provided by NPL (E04070170) with an original activity concentration of 1.017 Bq/g ± 0.8%.

6.2.3 Management of results and samples

The results from Genie 2000 are stored in a CIEMAT depository. The LID is computed by using the Currie criteria. The activity calculations are done by means of VBA (Visual Basic for Applications) in Excel sheets. The spectra are analyzed with standard sequences of Genie 2000 software.

URA y VR has a database within which the results are stored. From this database the different reports are filled in. Quality control data is also sent to CSN in the keeper format.

The samples are returned to the client upon completion of measurements.

7 VERIFICATIONS

7.1 INTRODUCTION

Verification activities were carried out in accordance with the agreed programme. This chapter summarises the verifications carried out by the verification team. The team has assessed the monitoring arrangements based on their own expertise and comparison with similar arrangements in other Member States.

The outcome of the verification is expressed as follows:

- A '*Recommendation*' is made when there is a clear need for improvement in implementing Article 35 of the Euratom Treaty. These are included in the main conclusions of the verification. The Commission requests a report on the implementation of the recommendations – lacking implementation of a recommendation or non-submission of the report can lead to a reverification.
- A '*Suggestion*' is made when the verification team identifies an action, which would further improve the quality of the Article 35 implementation.

In addition, the team may '*commend*' particularly good arrangements, which could serve as a best practice indicator for the other EU Member States.

7.2 PLUTONIUM CONTAMINATED AREAS IN PALOMARES

7.2.1 General

The contaminated areas in Palomares constitute an existing exposure situation in the sense of Articles 72-73 and 100 - 102 of the Directive 2013/59/Euratom laying down the basic safety standards. The Palomares Environmental Radiological Surveillance Program and the Environmental Radiological Recovery Programme carried out by CIEMAT constitute the required environmental monitoring programme.

CSN and CIEMAT have established a protection strategy for Palomares, which includes objectives and long-term goals for radiation protection, delineation of the affected areas and identification of the affected members of the public. Protective measures and access control are in place where necessary. No other restrictions on living conditions have been established. Assessment of the exposure of different groups in the population has been carried out - the existing exposure situation in Palomares has been thoroughly identified and evaluated, and Spain has in place a strategy for management of the Palomares contaminated area. Responsibility for the management of the strategy has been assigned to CIEMAT, under the supervision of the CSN.

CIEMAT communicates with the local authorities about the activities carried out in Palomares within the scope of the Environmental Surveillance Plan. The CSN issues information about the results of the monitoring program around Palomares through the annual CSN's report to the parliament and through the CSN's online application in its website. Currently, the CSN is working in including information about the results of the special Spanish monitoring programs in its annual environmental monitoring results publication, including the Palomares program.

CIEMAT has regularly carried out evaluations of the protective measures. Information about the levels of contamination to the exposed population is in place, but currently CIEMAT does not actively provide guidance for the management of exposures at individual and local level.

> *The verification team suggests that the CSN and CIEMAT review the current need to provide additional information about the health risks and guidance on the management of exposures on local and individual level.*

7.2.2 Air sampling

Radioactivity concentration in in air is monitored by three high-volume air samplers (Fig. 8-10). The samplers are equipped with flow counters, which are calibrated annually. The filter is changed and analysed weekly. The sampler located at zone 2 and the sampler close the zone 2-bis are placed in a metal gage providing very strong intruder protection.

No remarks.

7.2.3 Deposition sampling

Deposition sampling is carried out by funnels placed on container buckets (Fig. 11). The collection area of the funnel is 0.058 m^2. The sample is collected monthly, i.e. each month the programme includes analysis of three deposition samples.

No remarks.

7.2.4 Access restrictions and information to the public

Zones 2, 2-bis and 3

Access to zones 2, 2-bis and 3 is restricted by a metal fence, which is sufficient to provide a physical barrier to anyone trying to enter without tools to the restricted area. Information to the public is provided by signs placed on the fence. These signs inform about the access restriction, but do not provide information about the radiological hazard.

Zone 6

Zone 6 is large and located in a hilly terrain. Surface contamination originates from the actual impact zones – apparently carried by wind soon after the accident. No remediation activities have taken place in this area. Access is restricted by a light metal fence, which provides a sufficient delineation function but because of the hilly terrain, it´s coverage is not sufficient to provide a physical barrier to anyone trying to enter (there are places where an intruder can crawl under the fence to enter the area).

Information to the public is provided by signs placed on the fence. These signs inform only about access restriction, but do not provide information about the radiological hazard.

The verification team suggests, in line with the general recommendation in section 7.2.1, that the CSN considers the benefits and drawbacks of adding a radiation warning symbol to the information signs on the fences.

The verification team suggests further improvement of the zone 6 fence so that the fencing is adapted to the hilly terrain, providing an equal physical barrier on its entire length (no possibility to crawl under it to enter the area).

7.3 ASSOCIATED LABORATORIES

7.3.1 CIEMAT Palomares laboratory

CIEMAT Palomares on-site laboratory is a sampling and sample pre-treatment facility, which does not carry out analytical work. It is well equipped with necessary sample collection tools for sample pre-treatment before sending to the analytical laboratory in Madrid.

No remarks.

7.3.2 CIEMAT RERA laboratory

CIEMAT RERA laboratory in Madrid is a well-equipped and modern radioanalytical laboratory. It has a very good laboratory building and a modern set of analytical equipment for maintaining the Palomares programme. The laboratory is not accredited. It has taken part in intercomparison exercises organised by the CSN in 2014. Since then, and until 2018, CIEMAT have lost participation in 2016-2017 due to the improvement works carried out in the laboratories and the delay in the acquisition of a gamma detector to replace a broken device.

Verification team was informed, that at the time of the verification the laboratory had no capability to measure plutonium. Currently ^{241}Am is the only monitored radionuclide; $^{239+240}$Pu should be also quantified but this radionuclide was not being determined due to different reasons, such as construction works to improve the laboratories, delays in the acquisition of a broken detector caused by budget cuts and the lack of laboratory technicians while facing delays in the hiring process. The verification team was informed, that RERA intends to resume alpha spectrometry capability (Plutonium determination) in 2020.

The verification team recommends that the CSN require recovery of the RERA laboratory plutonium measurement capability as soon as possible.

The verification team suggests that the CSN require more frequent RERA participation in national or international intercomparison exercises or proficiency tests.

7.3.3 CIEMAT Quality control laboratory

The CIEMAT quality control laboratory (Environmental Radioactivity Unit and Radiological Surveillance URA y VR) carries out the quality control programmes of other CIEMAT laboratories. Some 5-10% of the Palomares samples are re-analysed in the URA y VR.

The laboratory is very well equipped and staffed for controlling the quality of both gamma spectroscopy and alpha spectroscopy determinations of the Palomares programme. It is accredited under ISO 17025 and participates in several inter-comparison exercises annually.

The verification team commends the CIEMAT extensive and substantial quality control programme.

7.4 FOLLOW-UP OF THE 2010 RECOMMENDATIONS

The verification team reviewed the recommendations issued in 2010[5]. Table VIII below summarises the recommendations and their follow-up.

Table VIII. Follow-up to the 2010 recommendations

Recommendation 2010	Follow-up 2019
Taking into account the very long half-lives of the radioactive contaminants in Zones 2, 3 and 6, the verification team recommends the remediation of the contaminated land. *Considering that within the contaminated areas, some locations give rise to potential radiation exposures for members of the public of more than 1 mSv per year, exceeding in certain zones 5 mSv per year, the team recommends applying the Spanish rehabilitation plan and cleaning up the concerned land to avoid any unacceptable radiological risks including those in the distant future: The Pu contaminated soil should be removed and safely deposited for long term storage. The team stresses the high importance of the cooperation of the US government with*	**Not completed**. Pending a binding remediation agreement with the United States, no remediation activities have taken place on any of the contaminated areas.

[5] Verifications under Article 35 of the Euratom Treaty, Technical report ES-10/01, 2010 (https://ec.europa.eu/energy/sites/ener/files/documents/tech_report_spain_palomares_2010_en.pdf)

Spain to overcome the socio-economic consequences of the disaster. *The assistance of the U.S.A. to Spain for the management of the radioactive wastes generated by the remediation of the contaminated land is judged to be of primordial importance in order to provide a final solution to this problem knowing that Spain has no facilities for the final storage of these Pu contaminated materials.*	
For the remaining areas with soils contaminated to a lower degree, the development of administrative solutions for the very long term is recommended in order to avoid any future uses of the affected areas that could lead to an unacceptable population exposure.	**Completed.** Administrative arrangements including access and land use restrictions are in place for all the contaminated areas.
For the short term, the verification team encourages installing improved fences with more warning signs, in particular in zone 6.	**Completed**. Fences and warning signs are in place on all contaminated areas. Improvement in public information could be achieved by including a radiation warning symbol (sticker) in the existing warning signs.
With a view to improve the radiation exposure estimates for the most affected members of the local population the team suggests to widen the surveillance programme to include rabbit meat (e.g. bought from local hunters).	**Partially completed**. Rabbit meat has been sampled occasionally, but there has been difficulties to obtain the samples. Different alternatives for the collection of the samples are being analysed.
The verification team endorses the continuation of the environmental radioactivity monitoring currently performed by CIEMAT.	**Completed**. CIEMAT is continuing the regular surveillance programme.

8 CONCLUSIONS

All planned verification activities were completed successfully. The information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, proved very useful.

The information provided and the verification findings gave rise to the following observations:

(1) The verification activities found that the facilities needed to carry out continuous monitoring of levels of plutonium contamination in air, water, soil and agricultural products in the Palomares accident area are adequate. The Commission ascertained that these facilities are in operation and running efficiently.

(2) One recommendation concerning temporary unavailability of certain laboratory capabilities has been formulated. Notwithstanding this remark the verified parts of the monitoring system for environmental radioactivity in Palomares are in conformity with the provisions laid down under Article 35 of the Euratom Treaty.

(3) In addition, the verification team points out that the 2010 recommendation concerning the remediation of the Palomares contaminated area has not been implemented.

(4) The team's recommendations are set out in the 'Main Conclusions' document addressed to the Spanish competent authority through the Spain Permanent Representative to the European Union.

(5) The Commission services kindly request the Spanish authorities to submit, before the end of 2020, a progress report on how the team's recommendations have been implemented and on any significant changes in the set-up of the monitoring systems.

In addition, the Commission services request the Spanish authorities to inform about the progress on the final remediation plan of the Palomares contaminated areas before the end of 2021.

Based on these reports the Commission will consider the need for a follow-up verification in Spain.

(6) The verification team acknowledges the excellent cooperation it received from all people involved in the activities it undertook during its visit.

ANNEX 1 – Verification programme

EURATOM ARTICLE 35 VERIFICATION SPAIN (PALOMARES)

18 – 20 June 2019

Tuesday 18 June

09.00 Opening meeting
(Hotel Best Oasis Tropical, Urbanización Marina de la Torre
Paseo del Mar, 1, 04638 Mojácar, Almería)

- European Commission Art. 35 verification programme introduction
- Review of recommendations given by the Commission in 2010
- Overview of protective measures and public information arrangements in Palomares
- Overview of environmental radioactivity monitoring arrangements in Palomares
- Petitions and written questions in the European Parliament
- Verification planning

13.30 Verification of on-site monitoring facilities and protective actions
(Palomares area)

- Access restrictions
- Information to the public
- Dose and dose rate monitoring
- Air sampling
- Dry/wet deposition sampling
- Soil sampling
- Water sampling

Wednesday 19 June

09.30 Verification of associated regional laboratories
(Almeria / Palomares area)

13.30 Other monitoring arrangements
(Palomares area)

Thursday 20 June

09.30 Verification of associated national laboratories (CIEMAT)
(Avenida Complutense 40, Madrid 28040)

- Environmental Radiological Recovery Program (RERA)
- Environmental Radioactivity and Radiological Surveillance Unit (URA y VR)

14:30 Meeting with the national competent authority (CSN)
(Justo Dorado 11, E - 28040 Madrid)

- Future monitoring needs in Palomares
- Remediation plan of Palomares
- Future work on European Parliament questions and petitions