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► **To cite this version:**

Lucie Cez, Regis Vallet, Lionel Darras. The Hydraulic System of Larsa (South Iraq). 13th International Congress on the Archaeology of the Ancient Near East (ICAANE13), University of Copenhagen, May 2023, Copenhagen, Denmark. hal-04473720

**HAL Id: hal-04473720**

**<https://hal.science/hal-04473720>**

Submitted on 23 Feb 2024

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## **The Hydraulic System of Larsa (South Iraq)**

*Lucie Cez<sup>1</sup>, Régis Vallet<sup>2</sup>, Lionel Darras<sup>3</sup>*

*Since the reopening of the mission in 2019, the water supply of Larsa has been a central focus of field investigations on this urban site of South Mesopotamia (Iraq). The first map of its hydraulic network can be established thanks to the cross-analysis of photogrammetric and geomagnetic images, to which is added the data of the geo-archaeological study and archaeological operations. In its final state, the intra-mural network had more than a hundred canals including several large ones such as the Grand canal, more than 22 m wide, basins of storage, the largest reserve in the north-west had a 26,000 m<sup>2</sup>, irrigation and drainage canals, but also a port area of 31,645 m<sup>2</sup> to the south. This approach made it possible to establish the connection with the canals works of the surrounding plain structuring the peri-urban network and to apprehend the major developments during the 2<sup>nd</sup> millennium, between the King Gungunum reign (1932-1906 B.C.) and that of King Sin-iddinam (1849-1843 B.C.).*

### **1. Introduction**

Although it was crucial to the development of Larsa (Tell es Senkereh) (Fig. 1), the 200 ha city dominating the Mesopotamia at the beginning of the 2<sup>nd</sup> millennium BC, its water supply has never been specifically studied. The existence of large canals crossing the Uruk plain, some of them located in the vicinity of the site and oriented towards it, is known thanks to the archaeological and geomorphological surveys as well as the historical sources (Adams and Nissen 1972; Adams 1981; Geyer and Sanlaville 1996; Pournelle 2003; Steinkeller 2001). Until the resumption of fieldwork in 2019 (Vallet 2020, Vallet *et al.* 2020, Vallet 2022; 2023), the available data was limited to large traces visible on the series of aerial photographs from G. Gerster (1973) to the north of the site. The imprint of large structures will give rise to divergent interpretations: as large roadways or large canals according to the authors (Huot, Rougeulle and Suire 1989; Margueron 2013: fig. 111), none however relayed by archaeological data.

The study of the hydraulic system of Larsa consisted first of all in reconstructing the organization of the hydraulic works inside the city, that is the network of canals allowing its supply and including possible basins allowing the water management. At a larger scale, it is also a question of establishing the connexion between internal hydraulic network and large canals crossing the lowland of the Euphrates River where Larsa was located. Finally, the objective pursued was to understand the general

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functioning of the system (water source, flow direction), specifically due to its insertion within the urban fabric, as well as to establish the history of its evolution over time.

## **2. A cross-analysis for identifying the canals network**

To meet these objectives, an interdisciplinary and multi-scalar research was implemented in 2019. This is based on the contributions of geophysics, photogrammetry and geo-archaeological field study and archaeological operations (Vallet 2020; Vallet, Cez and Darras 2022: 34-36).

In order to highlight the layout of ancient canal works and other hydraulic structures, the carto-photo-interpretation work relied on the ortho-photos by drone (Suire and Lisein 2020), satellite image and ancient aerial photographs of the site, crossed with the geophysical image from the geomagnetic survey. 70 hectares of the site and its immediate surroundings were explored over the period 2019-2023 with the geomagnetic method, which provides an image of the built and dug structures of the basement, up to 2 m deep (Aspinall, Gaffney and Schmidt 2008). All of this high-resolution and georeferenced documentation has been integrated into a Geographic Information System (GIS) built using QGis software, in which the map of the hydraulic system has been drawn.

On the field, the geo-archaeological survey enabled to identify many canals, detectable by their typical morphology of large depression delimited by marked levees, and whose upper sandy filling is punctuated by scattered xerophyte shrubby vegetation (Fig. 2). Following their relatively rectilinear route on the ground over a certain distance makes it possible to distinguish constructed canals from wadi beds, especially if branches are still visible. The significant silting up of the site, mainly in the form of barchan-type dunes and sand toppings of varying thickness, however, makes annual photogrammetric coverage essential. With the dunes displacement, structures can be thus detected in previously silted sectors.

## **3. The map of the Larsa hydraulic system**

This methodological approach allowed the identification of more than a hundred of canal layouts of variable sizes and eighteen storage basins on which the hydraulic system of Larsa, in its final state, was based (Fig. 3). Such a very complex network extended over approximately one 1,200 ha including the intra-mural network and the peri-urban one, no less dense. In total, 124 canals were numbered in the first map produced in 2022 (Vallet, Cez and Darras 2022: 35) but this is bound to evolve because some sectors are still unexplored in geomagnetic prospecting. Remember that less than half the size of the Larsa site, of 200 ha of extension, has been covered to date by geophysics survey. The main limit to the detection of fossil urban and hydraulic structures, however, remains significant silting up of the eastern part of the city, which have provided much less data, and that of the area south of the site where coalescent dune fields cover the plain.

### 3.1. *The north-east sector*

Originating from the northeast, the canal labelled C1 in the general map of the hydraulic system was the most important structure for water supply of the city. Its layout has been identified over a distance of 1.2 km thanks to the drone coverage but previous archaeological and palaeohydrological surveys highlighted from the Tigris near Zabalam, 62 km from Larsa, to Bad Tibira, 17 km away, and beyond. But its final section, the connection to Larsa, was missing (Adams and Nissen 1972: 36-39; Pournelle 2003: fig. 76). This canal was established as the main supply of the city during the reign of Siniddinam (1849-1843 B.C.) (Sigrist 1990: 24; Frayne 1990: 158-160; Steinkeller 2001). This latter work probably replaced an older canal of lesser importance, part of which was dated to the Ur III period (2112-2004 B.C.) (Adams and Nissen 1972: 39). Its entry point into the city was located about 100 m north of the Parrot Gate (East Gate B1), where a massive gate allowed passage through the rampart and here called watergate B65 (Fig. 3). The C1 canal work, 30 to 20 m wide in the plain, was reduced to 5 m wide at the crossing point in the city as it is shown by the geomagnetic image (Fig. 4). Reducing the size made it possible to increase the flow speed and the water height. The powerful earth dykes framing the canal all along its course on the plain (D1-D2) were reinforced before it entered the city and associated with a lateral embankment to the south, itself topped by a baked brick wall. Such a device was intended to support the pressure exerted by the water in the canal work due to its curved layout. The Watergate B65 itself was fitted out for the water circulation, notably the semi-circular shape of the two internal faces of the baked-brick piers, 43 m in length for a maximum of 20 m large. The C5 canal was designed as a relief canal for part of the flow of the C1 canal before its entry into the city, while the valve C6 had to evacuate the overflow of water towards the plain, the latter also having a defensive role since it allowed the surroundings of the eastern gate of the city to be flooded<sup>4</sup>.

Once through the Watergate B65, water was transported to the center of the city by a succession of large canals forming a loop (C1-C4) (Fig. 3). The canal C2 formed a large curve to the north over 1.2 km, then continued south with the canal C3 until the ziggurat in the city centre and, finally, turns to the southeast by the narrower canal C4, to leave the city. The 'Grand Canal' (C3) is the main artery of the internal system, 22 to 25 m wide, and was flanked on the west by a large landing stage and a high dyke, revealed by geomagnetic prospecting (Fig. 5). The geophysical image clearly shows the piers of two bridges at its northern and southern ends, extended by causeways of which some portions of their rectilinear lines have been found (see roads 51, R2, R3 and R10 in Fig. 3). This shows that the hydraulic works were perfectly integrated into the urban structure of Larsa. The ongoing excavation of the east pier of the south bridge B69 has already revealed 8 courses of baked bricks for a depth of

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<sup>4</sup> Fan-shaped flood traces originating at the outlet of the valve and the plugging of the Parrot Gate entrance with raw brick as well as abundant projectiles found on-site support this hypothesis (Parrot 1933: 177 ; Huot, Rougeulle and Suire 1989: 40). The technical characteristics of this hydraulic system and in particular of the north-eastern part of the city articulated around the Watergate B65 will be detailed in a special publication to come.

nearly 1 m (Fig. 6a) (Zingarello, Bachelot and Hsony 2022: fig. 2). The upper's courses of the pillar yielded an inscribed brick of king Sin-iddinam (Charpin and Jacquet 2022: fig. 6) (Fig. 6b).

### 3.2. *The north-west sector*

The canal C2 supplied the northwestern part of the city by the C7 canal of diversion reinforced with two side dykes due to the large quantities of water redistributed here (Fig. 5). The water of C7 was also diverted towards the west by other canals of variable sizes. The other work linking the Grand Canal and the western sector is the C9 canal, which runs along the Nur-Adad Palace and joins the P1 basin at its northwest extremity (Fig. 3).

The distinctive feature of the western zone from the point of view of its hydraulic works is that it houses a set of water storage basins. The P1 storage system was composed of several and connected basins covering a 6,640 m<sup>2</sup> area (Fig. 3). Its modular plan probably results from successive additions over time. The most important storage work of the city was the huge P2 reserve of 26,000 m<sup>2</sup>, whose clear signature on ortho-photos by drone (Fig. 7) is partly explained on the field by the density of carbonate concretions and mollusc. The location of such a structure takes into account the flat topography of this western sector of the city. These basins were indirectly fed by the Grand Canal via the C7 secondary canal for the basin P1 and via C9-C15 canals for the basin P2.

The geomagnetic prospecting also revealed an irrigated plot on the edge of buildings B48 and B49 and connected to this P2 reserve by canals C20 and C22 (Darras 2020: fig. 5; Vallet, Cez and Darras: fig. 14) (Fig. 3). A network of irrigation canals intersecting at right angles fed this geometric plot, while a drainage canal C23 ran from its southwest corner in order to evacuate waters outside of the city. Many incomplete sections of canals of this type around the P2 reserve suggest that this must have been an area of the city dedicated to irrigated agriculture<sup>5</sup>.

### 3.3. *The south sector*

Spatial organization and functioning of the south hydraulic network is not yet fully understood. High silting up and numerous gullies of wadi blurred the ancient hydraulic works traces or has widened and scoured their original profile. The canal C26 is the major work in the southern zone, starting from the central basin P5 and flowing southeast to the Watergate B17 designed according to the same scheme as the Watergate B65 to the northeast, but with more modest dimensions of 37 m in length for 10 m large (Fig. 3). The central basin P5 probably collected rainwater, surrounding flows and the waters drainage of the E-babbar, but it should be also connected with the city network from the northeast. The other important work was the C27 canal, with a still incomplete layout to this day, but which has

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<sup>5</sup> The nature of artefacts uncovered by the pedestrian survey (Giraud *et al.* 2022), with sickle blades and lithic material, is consistent with an agricultural function dominant in the sector.

branches of secondary canals.

At the periphery of the southern area, a vast port zone of 30,000 m<sup>2</sup> was identified on either sides of the rampart (Fig. 8). The external basin followed the enclosure contour, protected by a 17 m wide dyke. Access to the internal smaller basin was by the west through the rampart, by two passages of 4 m wide and 25 m apart. Access to the port from the south was by a canal ten meters wide. The limits of the inner basin are less clear but had probably two docks, a main and a secondary. Associated with this port basin in the city, the function of the large rectangular building B57, of more of 4,000 m<sup>2</sup>, known for a long time and that yielded several inscribed bricks of king Sin-iddinam, finds a new interpretation (Huot, Rougeulle and Suire 1989: 50; Vallet and Suire 2020: 58). It was probably devoted to storage in the view of its partitioned internal organization, and more specifically a warehouse of the port.

#### **4. The peri-urban hydraulic network**

Around the city, the density of the peri-urban network is also impressive, especially since the barchan fields prevents the visibility of a large number of ancient canals in the south of the plain. Everywhere else in the close vicinity of the city, the deflation exerted on the former topography by the prevailing winds reveals their fossil layouts. Except the C1 canal to the northeast which continues into the city, the large peri-urban canals bring water to key points, where it is collected and redistributed. The many observable overlaps between the canal works show that not all of them were operational at the same time. An analysis of overlaps and doubling of canals is therefore to be done to periodize and characterize the different states of the network over time (Fig. 9). Four phases could be identified, corroborated by historical data, enhancing successively the different parts of the city during the 2<sup>nd</sup> millennium B.C. (Fig.3).

The oldest system (phase 1) established west of the city is attributable to king Gungunum (1932-1906 B.C.), sovereign which initially erected the city wall enclosure in the 21<sup>st</sup> year of its reign (Sigrist 1990: 9-10) and who carried out hydraulic works, which is reflected in the large number of '*year names*' celebrating the digging of canals (Charpin 2002: tabl. 1). Two large canals organized the network, each 15 m wide, C37 and C88, fed by the Iturungal and the Euphrates (Fig. 3). The water was thus brought to the closest to the city at the Watergate C19. Inside the city, the canals C19 and C16 should correspond to this most ancient system. The extension of this first network to a larger territory (phase 2) was carried out under the reigns of Abi-sare (1905-1895 B.C.), son and successor of Gungunum, then Sumu-El (1894-1866 B.C.). Historical sources attribute the strengthening of the city wall and the digging of the '*hiritum*' water ditch to the king Abi-sare (Frayne 1990: 149; Sigrist 1990: 12-13). According to our hydraulic system reconstruction, the hydraulic works of this phase were the large basin P9 redistributing water to the west by the canal C39 and to the north by the canal C95 (Fig. 3). Several mapped hydraulic works could correspond to the '*hiritum*', among them the internal canal

C19 or the peri-urban ones C34, C36 or C44<sup>6</sup>.

Further developments of the hydraulic network (phase 3) took place during the reign of the king Nur-Adad (1865-1850 B.C.), especially in the northwest and southwest parts, which have been split. The large canal C38 was built about 200 m west and parallel to the former one C88, fed by the Iturungal or further by Euphrates River (Fig. 3). The same process can be observed with the canal C50 coming from the northwest and which splits the previous C49. Such developments made it possible to increase the water supply for the city in the political context of rivalry between Isin and Larsa cities and which had led to a break in the water supply of the latter, under the reign of Nur-Adad (Charpin 2002: 556-557; Charpin 2004: 102).

The most recent system (phase 4) corresponds to the large hydraulic works program of the king Sin-iddinam (1849-1843 B.C.) previously described (infra). It specifically develops the eastern part of the network, including the C1-C4 loop, which involves a new water source from the Tigris River (Fig. 3). Such a reorganization of the hydraulic system is understandable in light of the difficulties of its predecessor Nur-Adad to insure the fresh water to its city from the Euphrates (Charpin and Jacquet 2022: 148). The canal C1 coming straight from Bad Tibira, about 17 km northeast of the site, is the backbone of the whole system: not only does the C1 canal supply the city's internal network but numerous canals divert its water to the north before entering Larsa. This northern network developed from several branches derived from C1 canal (C94, C95, C92) and integrated old sections of palaeochannels, more or less regularized (C90, C91 and a section west-east of the C92).

The entire system became considerably denser over time required large-scale water management. This was the objective of the huge reservoirs located in the plain, about 1.2 km north of the city wall. They were located in the heart of a vast agricultural area where other smaller reserves of water, canals and fossil plots have been identified during the last field campaigns of 2022. These structures had a geometric and modular plan resulting from successive enlargements of its outer limits to meet growing water needs.

## Conclusion

Our knowledge of the general urban organization of Larsa and of its hydraulic network has made great strides since the resumption of fieldworks in 2019. The first map of its water supply system presented to the 13<sup>th</sup> annual conference of ICAANE was produced with support of photogrammetry, geophysics and geoarchaeology, an effective methodological approach enabling to identify fossil traces of hydraulic structures and their functional interpretation. The coexistence and high density of hydraulic works for water conveyance (canals of large templates and secondary), storage (basins of variable sizes, large reserve), irrigation and drainage (canals and canalizations) and protection (dykes) gives the

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<sup>6</sup> It is not established that this hydraulic structure is necessarily external to the rampart like a moat (see Charpin and Jacquet 2022: 147-148).

Larsa system its degree of complexity. The technical and functional developments of this system during the 2<sup>nd</sup> millennium B.C. show that the question of the city's water supply was a crucial issue for the daily life of its inhabitants, who had domestic, agricultural and artisanal uses as on the political level for the subsistence of the population, accessibility and defence.

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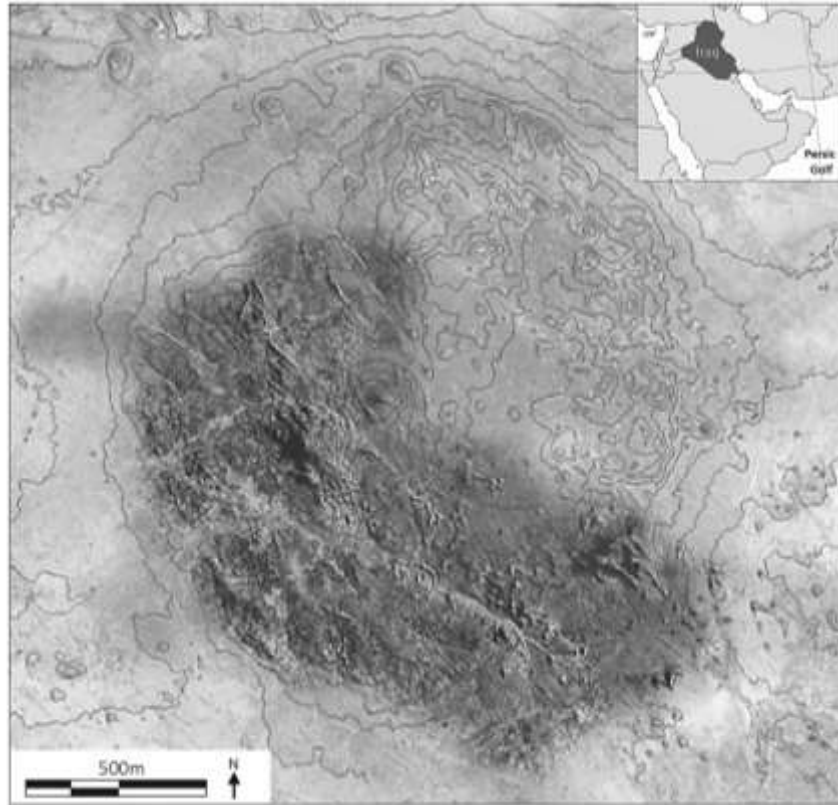


Fig. 1. The Tell of Larsa with contour lines (1 m) in the lower plain of the Euphrates River (southern Iraq).  
© Mission of Larsa-Uwaili, 2022.



Fig. 2. The 'Grand Canal' C3 looking north as a depression filled with sand and shrubs. © L. Cez, November 2021.

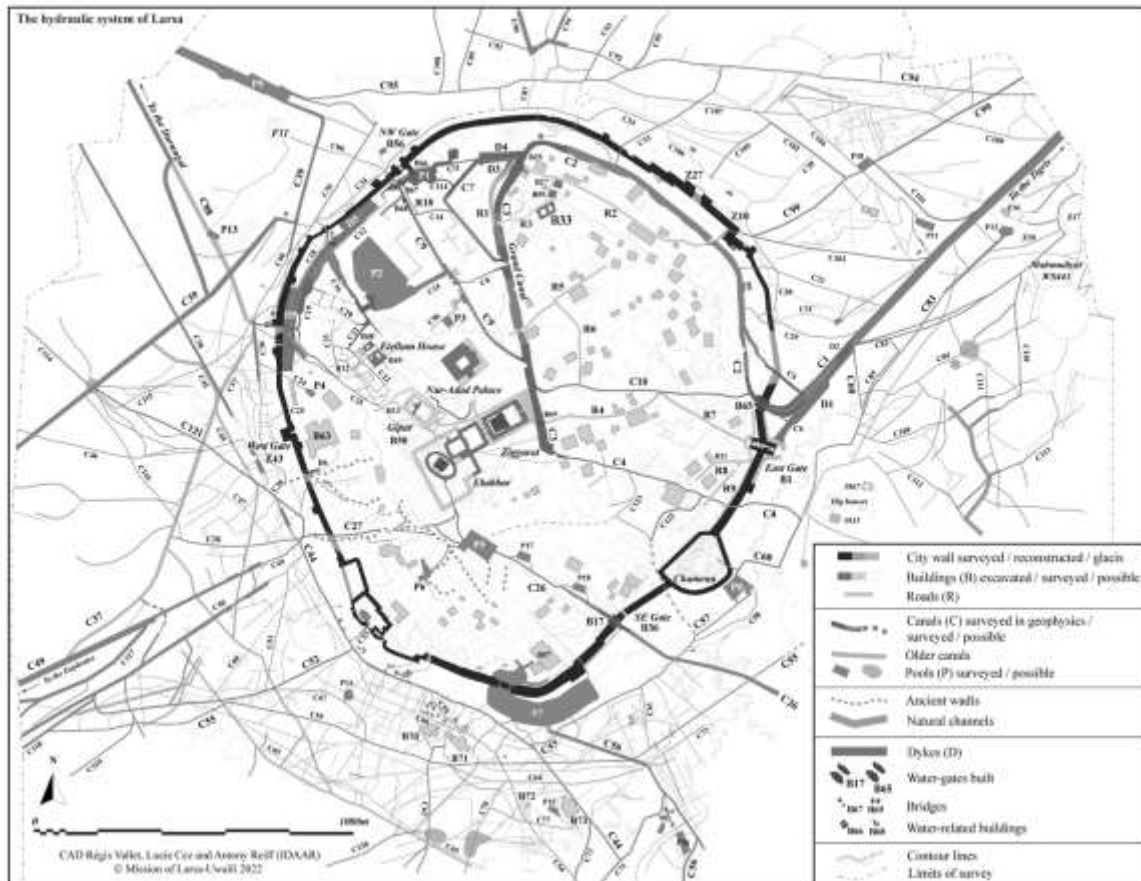


Fig. 3. General plan of the urban structure of Larsa and its hydraulic system. CAD R. Vallet, L. Cez, A. Reiff (IDAAR). © Mission of Larsa-Uwaili, 2022.



Fig. 4. Geomagnetic image showing the canal C1 before entering the city, with lateral embankments and the Watergate B65. © L. Darras and Mission of Larsa-Uwaili, 2022.



Fig. 5. Geomagnetic image showing the hydraulic network of the north of Larsa. White box highlights the magnetic anomalies of the baked bricks piers of the bridge B25 (north). © L. Darras and Mission of Larsa-Uwaili, 2022.

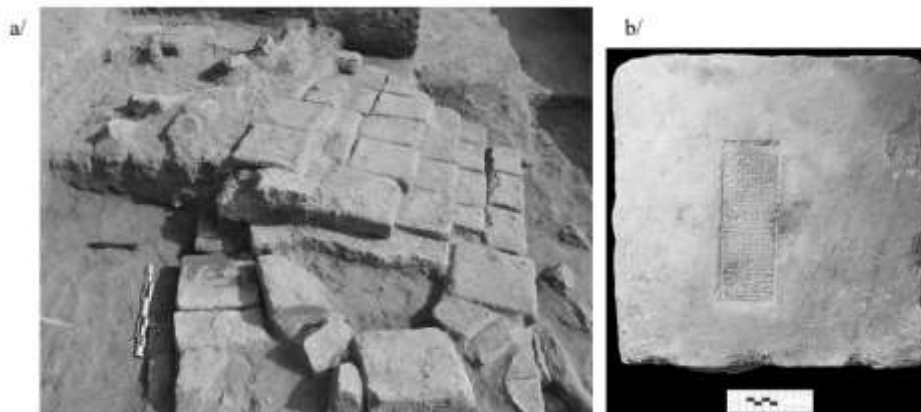


Fig. 6. The east pillar of the south bridge B69 of the Grand canal (a). Inscribed brick of king Sin-iddiman (b). © Mission of Larsa-Uwaili, 2022.

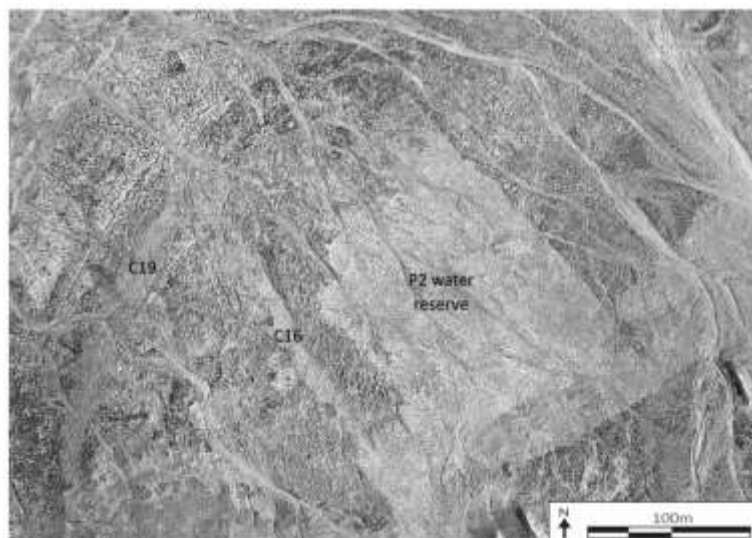


Fig. 7. Identification of the quadrangular water reserve P2 in the northwest sector. © Mission of Larsa-Uwaili, 2022.

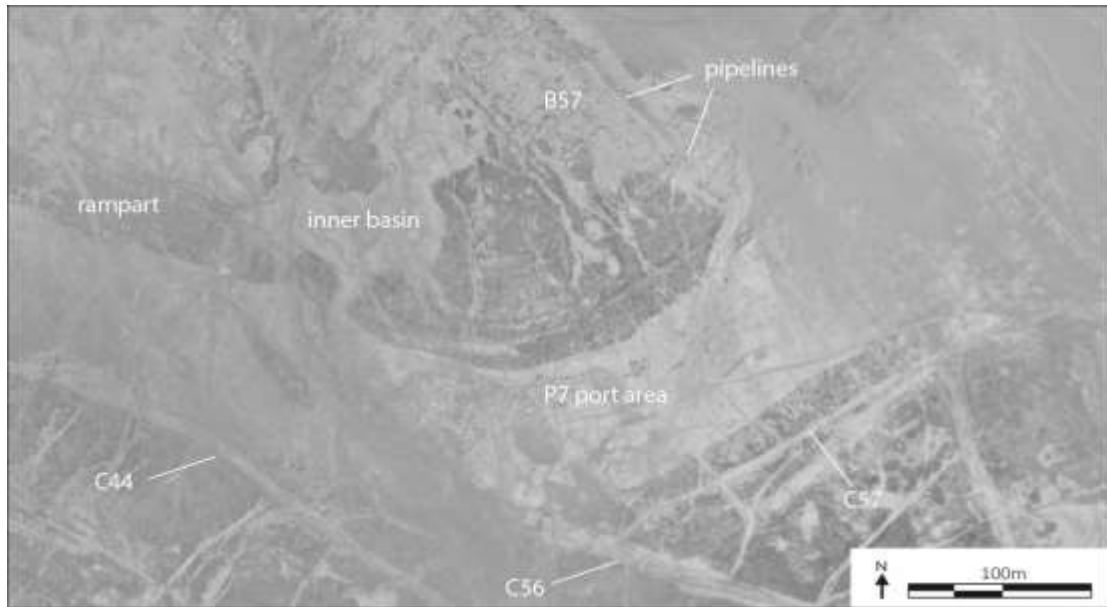


Fig. 8. The port area of Larsa in the south of the city. Drone image by J. Lisein. © Mission Larsa-Uwaili, 2019.

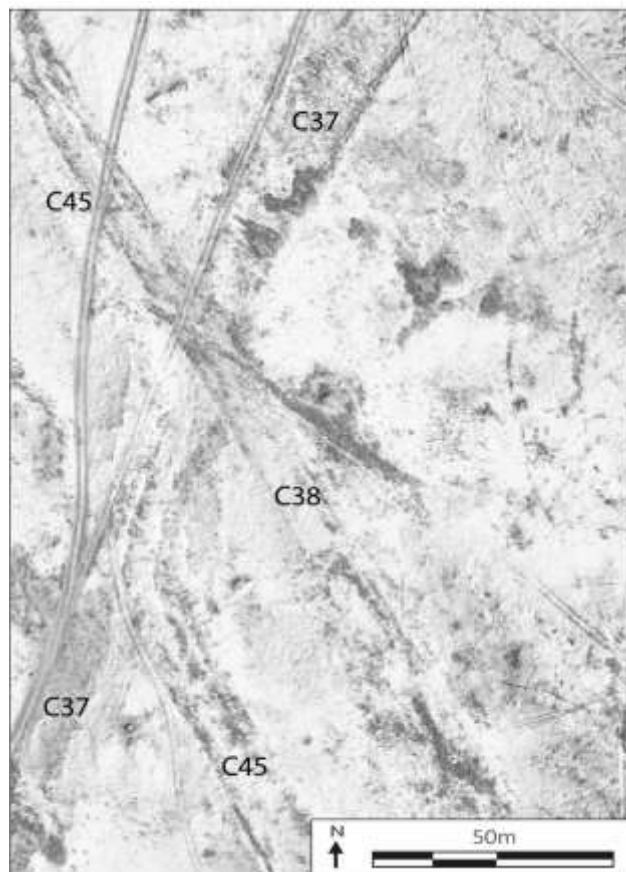


Fig. 9. Superposition of three generation of canals of the peri-urban network west of Larsa. Drone image by J. Lisein. © Mission Larsa-Uwaili, 2019.