2017

The Water System of Tall Jalul

Bruno Alves Barros
Andrews University, brunoabarros@protonmail.com

ABSTRACT

THE WATER SYSTEM OF TALL JALUL

by

Bruno Alves Barros

Chair: Paul Zeljko Gregor

ABSTRACT OF GRADUATE STUDENT RESEARCH

Thesis

Andrews University

Seventh-day Adventist Theological Seminary

Title: THE WATER SYSTEM OF TALL JALUL

Name of researcher: Bruno Alves Barros

Name and degree of faculty adviser: Paul Zeljko Gregor, Ph.D.

Date Completed: April, 2017

The Problem

Components of the water system of Tall Jalul have been discovered since 2009 in Fields G and W. Although articles and reports have been written, no comprehensive study has been conducted. Therefore, this thesis will present and discuss the water system of Jalul from 2009 to 2016 and look for comparisons with similar Iron Age structures in the Ancient Near East.

The Method

For this project, the ruins from Fields G and W were analyzed. First, selected water systems in Palestine were introduced, followed by a review of preliminary reports and personal observations on the site of Tall Jalul. Second, a literature review was done to find

similar structures in the Ancient Near East. Finally, a comparison between these structures was made.

The Results

Parallels to the water system of Jalul were found in the literature review, and a comparison between them was done, helping to understand their function as well as the function of the structures at Jalul with the evidence so far available.

Conclusions

It was possible to conclude that the Tall Jalul water system was unique in its size and function; however, not so developed in storage and water protection, as was the case with similar Iron Age water systems in the Ancient Near East.

Andrews University

Seventh-day Adventist Theological Seminary

THE WATER SYSTEM OF TALL JALUL

A Thesis

Presented in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Bruno Alves Barros

2017

THE WATER SYSTEM OF TALL JALUL

A thesis
presented in partial fulfillment
of the requirements for the degree
Master of Arts

by

Bruno Alves Barros

APPROVAL BY THE COMMITTEE:

____
Paul Zeljko Gregor, Ph.D., Chair

____
Paul J. Ray, Ph.D.

____
Randal W. Younker, Ph.D.

____
Date approved

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The site of Tall Jalul was settled in Early Bronze Age times, when people tended to settle or build settlements around water sources such as rivers or springs. Tall Jalul is located on an elevated area. It sits on the middle of Madaba Plains and it is surrounded by wheat and barley fields which still exist today. It is 5 km east of the modern city of Madaba in the Hashemite Kingdom of Jordan. It is one of the talls of the Madaba Plains Project and has been under excavation by Andrews University since 1992 and continues until the present, with only a few seasons of interruption. During this time archaeologists, students and volunteers from many parts of the world have been involved in the excavations and studies of this tall and its relationship with the Ancient Near East. The excavations have been directed by Randall W. Younker, Paul Zeljko Gregor, Constance E. Gane, and Paul J. Ray, of the Institute of Archaeology at Andrews University.

In 2007, a decision was made by the directors to open a new Field (G) located on the southeastern ridge of the tall. Work in that field continued in 2009, where remains of a water channel was discovered. The water channel seemed to lead towards a great depression, which the archaeologists suspected to be an ancient reservoir. For that purpose a new Field (W) was opened in that area in 2010 in order to investigate the depression. During the 2012 season, several additional squares were opened whose purpose was to reveal the continuation of the water channel and reservoir as well (Gregor 2014). Since then, the history and results of the excavations in both Fields G and W have been published in the Annual of the Department of Antiquities of Jordan, and written in various articles, but no comprehensive study has been written in regard of the water system of Tall Jalul.

The present study starts with a description of the water systems of the Ancient Near Eas, and focused on the different types, how they were constructed, their importance, and how they operated for their inhabitants at that time. Following that, a description of the water system of Jalul combined with the history of the excavations in Fields G and W was presented. In addition, in a search for similar structures, a literature review was made of seven different Iron Age water systems at six different sites, each one being described, and whenever present, the history of the excavations introduced. In the following chapter an attempt was made to compare those Iron Age water systems. In conclusion a comparison between them and the water system of Jalul.

This thesis is a descriptive project, and it does not intent identify the site, neither bring new data or solutions for the hypothesis raised during the reports of the excavations. The aim of this thesis is to describe and investigate the water system of Jalul and look for comparisons to similar Iron Age water systems in the Ancient Near East, particularly in Palestine.

CHAPTER 1

WATER SYSTEMS

General Description of Water Systems of the Ancient Near East

Water always played a primary role in the daily life of ancient peoples, especially in the ancient Near East, where the climate was arid and access of water was rare and precious. Water was needed for drinking and cooking, also being used in washing, producing pottery, watering crops, and livestock as well as in religious rituals (Bienkowski and Millard 2000, 317).

Unlike Egypt and Mesopotamia, where the agriculture was based on irrigation from the Nile, and Tigris and Euphrates Rivers respectively, Palestine depended upon seasonal rains. The short rainy season between November and March has averages of about 750 millimeters in the Mediterranean zone, decreasing to the south and east, is followed by a long dry season (King and Stager 2001, 123). Referring to the precipitation in the south and east of modern Israel and Jordan, Oleson notes that "not only is the rainfall meager in this area, but it is unevenly distributed in space and time, and the total amount that actually falls in a given area can vary dramatically from year to year" (Oleson 1992, 883). The high-intensity of rainfall also means high rates of runoff, and therefore, precious water that could be used to agriculture was lost (Hopkins 1987, 184). Considering the meager amount of rain throughout the year and the needs of humans, plants and animals (which could not live without water), settled populations in this region always worked with natural hydrology. The development of the water systems in the Middle East was the key to survival and prosperity, and activities to enhance the flow of the springs, direct, and store water were assisted throughout time by water works: tools or structures designed to manipulate the flow of water for human benefit (Oleson 1992, 883). Because the security of water was so important, it stimulated the appearance of formal local codes, regulating the use and management of water. As Oleson notes they consisted of "codification of informal rules of ownership, access, precedence, and maintenance that had evolved among earlier nomadic and settled groups in response to the demands of typical local situations" (Oleson 1992, 883).

The availability of water also was a determinant factor for the establishment of settlements from the earliest times. Cities were always established around water sources, but because of the need of protection in times of war, cities were built on hilltops for defensive advantages, far from water sources that were usually located at the base of the hill, outside of city walls (Cole 1980, 9). Once the size of populations grew, and consequently the "height of the cities themselves grew through successive re-buildings, creating higher and higher 'talls', the water supply moved progressively far away." (Cole 1980, 9). This situation created a problem for the inhabitants especially in periods of sieges that could last months and in some cases more than a year, and deprived the city of water supply. For that purpose, water works were developed throughout the centuries and water tunnels that were able to provide a safe access to the springs without exposing the cities' population to danger.

Water sources in Ancient Near East can be divided in various types. A spring (Figure 1) for instance, is a work of nature, in contrast to wells, open and underground reservoirs, and cisterns that are artificial methods. Springs also determined the location of settlements, explaining the location of many sites near of springs. (King and Stager 2001, 123). A spring can also be characterized by its purity of water, although in some instances, pools of water could attract significant human and animal traffic, and unimproved springs could become muddy and polluted (Oleson 1992, 884).

Figure 1. The Spring of Ein Gedi, Israel.

Nevertheless, some cities such as Byblos in the Bronze Age had a good plan to maintain the cleanliness of the spring's water, where a "small pool was dug out of a marsh below the spring to receive the flow and keep the area around it dry. The area was also kept free of habitations and burials for a radius of ca. 15 m." (Oleson 1992, 884).

In later periods, spring houses were introduced. They consisted of "structures designed to collect water, protect it from the sun and from pollution, provide convenient access to the flow, and occasionally to present an impressive facade" (Oleson 1992, 885). As a natural source, it can be assumed that springs were the first type to attract human populations by its purity of water and refreshment. However, well water, was also considered of high quality, especially when compared with cisterns and some kinds of reservoirs. Wells (Figure 2) were dug in order to gain access to the water table, and its water used mainly for human consumption and livestock. In order to facilitate the supply for the livestock, pools were constructed adjacent to the wells (King and Stager 2001, 125).

Wells are characterized as an artificial shaft that reaches an underground spring or water level that can be tapped (Negev 1986, 394). They were very common in the ancient Near East, especially in most desert regions, where other types of water sources are very limited. Although there is no literature from ancient Near East concerning instructions about how they used to dig wells, the basic procedures can be based in empirical experience. Observation of the topography, soil, surface, moisture, and vegetation are among of the procedures (Oleson 1992, 886). King and Stagger (2001, 124) suggest that the manner in which wells are excavated on archaeological digs today is not very different than the actual digging of the well: "By sinking a shaft to the water table, an aquifer or underground spring can be reached. To get there, workers make a circular hole about one

Figure 2. "The Moabite Well" Located in Madaba, Jordan.

and a half to two meters wide and begin to dig. To prevent collapse on the way down, the shaft must be lined by chocking in rough fieldstones. Often well houses or wellheads in the form of stone slabs cover the opening to prevent people and animals from falling in and to protect the water from contamination." Wells were found in cities such as Lachish, where they were available to the public, in private homes in cities such as Ugarit, or even inside of palaces, an example of this is the palace of Assurnasirpal II (884-859 B.C.) at Nimrud (Oleson 1992, 887).

With the lack of natural springs or other water sources, cisterns (Figure 3) were a necessity for settlements. However, even in places with many water sources, cisterns

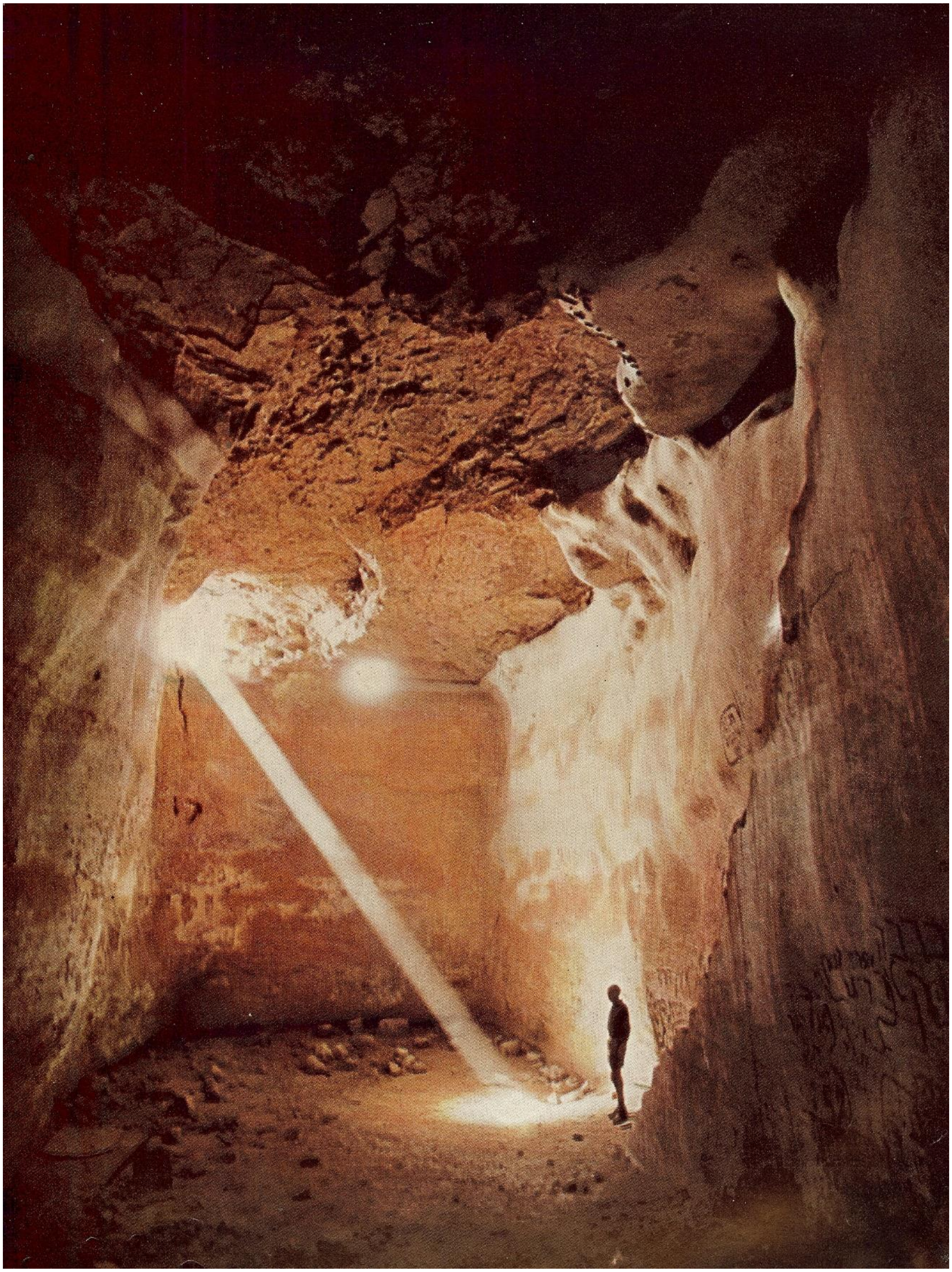

Figure 3. A Large Cistern Excavated From Solid Rock in Masada, Israel (Yadin 1984, 28).

were constructed to provide a low-quality water for irrigation, daily life activities, and to be an emergency reserve in times of war. The water in cisterns is characterized by its bad taste, lack of clarity, and healthfulness, and had a bad reputation among Greeks and Romans (Oleson 1992, 887). Cisterns are artificial reservoirs, cut into bedrock and plastered inside with lime to prevent leaking. Some cisterns, cut into hard limestone, did not require plaster once they were impermeable. They could be of different sizes and shapes, such as bottle-shaped and bell shaped (King and Stager 2001, 126-27).

The first cisterns were constructed during the Middle Bronze and Late Bronze age. The rainfall between November and March would be enough for at least one dry season. In the Iron Age however, cisterns began to be covered with watertight plaster, which allowed water to be stored for a more prolonged period of time (Negev 1986, 394). There is a quite difference between cisterns and reservoirs, Oleson notes that "in contrast to cisterns, which tended to be small and private, reservoirs were large, usually unroofed pools designed to store quantities of water for public use or for applications that required significant volume. They could be filled by springs as well as by runoff water" (Oleson 1992, 888).

Reservoirs (Figure 4) are very ancient, they appear as early as cisterns in the archaeological record. Reservoirs dating from the 4th millennium B.C. were discovered in Jawa, Jordan where a system of reservoirs were designed to be filled by runoff water (Oleson 1992, 888). This water could be used for livestock, irrigation and human consumption, although water from springs and wells were preferred over reservoir water, since they were usually unroofed, therefore getting polluted, and the temperature of the water higher than desired for human consumption (Prestes 2014, 58).

Figure 4. An Open Air Reservoir in Tell Hesban, Jordan.

Among other examples of reservoirs, are the pools of Solomon near of Bethlehem. They consisted of three large reservoirs fed by springs and they served Roman Jerusalem connected by aqueducts, and were expanded until Byzantine period (Oleson 1992, 888).

Throughout the ages, water systems became more and more developed. One of the periods that witnessed a great development, especially of subterranean water systems (Figure 5) was the Iron Age. These water systems were designed not only to provide an easier access to water, but also to supply the cities' population in times of war. Barkay, making reference to the water systems of Iron Age, suggests that "water systems may be divided into two types, those that bring the inhabitants to water and those that convey water to the inhabitants. Obviously the first method is the less sophisticated and hence earlier method" (Barkay 1994, 333).

Examples of less sophisticated methods, those with an external approach, are the Gallery 629 at Megiddo, dating to the 12th century B.C. and the system at Tell es-Sa'idiyeh. As Barkay describes "they consist of a covered passage through the city wall and a stairway descending along the slope to the spring. They appear to date to the tenth century" (Barkay 1994, 333). Other types such as shaft and-tunnel systems that linked the city to the spring are Shaft 925 in Megiddo, the tunnel system of Gibeon, Warren's Shaft in Jerusalem and the water system of Yibleam (Barkay 1994, 333).

The second method proposed by Barkay, included a more sophisticated method. Since a tall is usually located far above from the water source, he argues that "the problem was overcome by cutting a vertical shaft within the walls down to a tunnel that conveyed the spring water to the base of the shaft. The upper part of the shaft, cut through earlier occupation layers, had to be supported with massive retaining walls, while the lower part was hewn in the rock to a level slightly lower than the spring. Steps were cut along the sides of the shaft to provide access to its base. In some water systems, however, there was no access to the bottom of the shaft, and water was drawn from above by means of ropes and pails (Barkay 1994, 333). Mazar also proposes a typology of water systems of Iron Age. He argues that the first type consisted of underground shafts and tunnels (Figure 5) that would lead the settlers to a water source located outside of the town.

-

Figure 5. An Iron Age Underground Reservoir Located in Megiddo, Israel.

Examples of these kinds of water systems can be seem at Megiddo, Yibleam, Gibeon and Jerusalem, with different details of planning according to each site. A second type of water systems are those from Hazor, Gibeon and Gezer. The main features at these sites are a deep shaft followed by a tunnel hewn inside the city to the water level (Mazar 1992, 479-81).

Other scholars propose a further division between the northern group of water systems and the southern group. The northern group include Megiddo, Hazor, Gibeon and Gezer. All four cities had in common water systems that had shafts cut through the strata to tap the water table.

The southern group include Arad, Beth-Shemesh, Kadesh-Barnea, and Tel Beer Sheva where large cisterns and reservoirs were the main water works for the population (King and Stager 2001, 210-11). The (Figure 6) illustrates the different types of water systems in a Tall.

The dating of water systems has been debated among scholars. According to Barkay, there is no consensus yet regarding the dating of underground water systems. One of the main factors concerning when these water systems were founded. Water systems such as Gezer, Yibleam, Warren's shaft and Megiddo were discovered in the "early stages of the history of archaeology," when techniques were still developing and stratigraphic errors and other difficulties were most likely to occur (Barkay 1994, 333-34).

Shiloh argues that many scholars rely on "sparse pottery evidence" from different parts of the water system in order to date the structure. However, in his own experience of clearing water systems at Hazor and Jerusalem, it was clear that as a rule, those finds may not be relied upon solely, as pottery can be deposited in "various manners" and at "various times," and debris from structures that surrounded the water system can mix with the pottery. Therefore, ceramics alone are not a safe method for solid evidence. Shiloh proposes that "despite the difficulty of relating the components of the water systems to the surrounding stratigraphic series, this relationship holds the major key to accurate dating" (Shiloh 1992, 291).

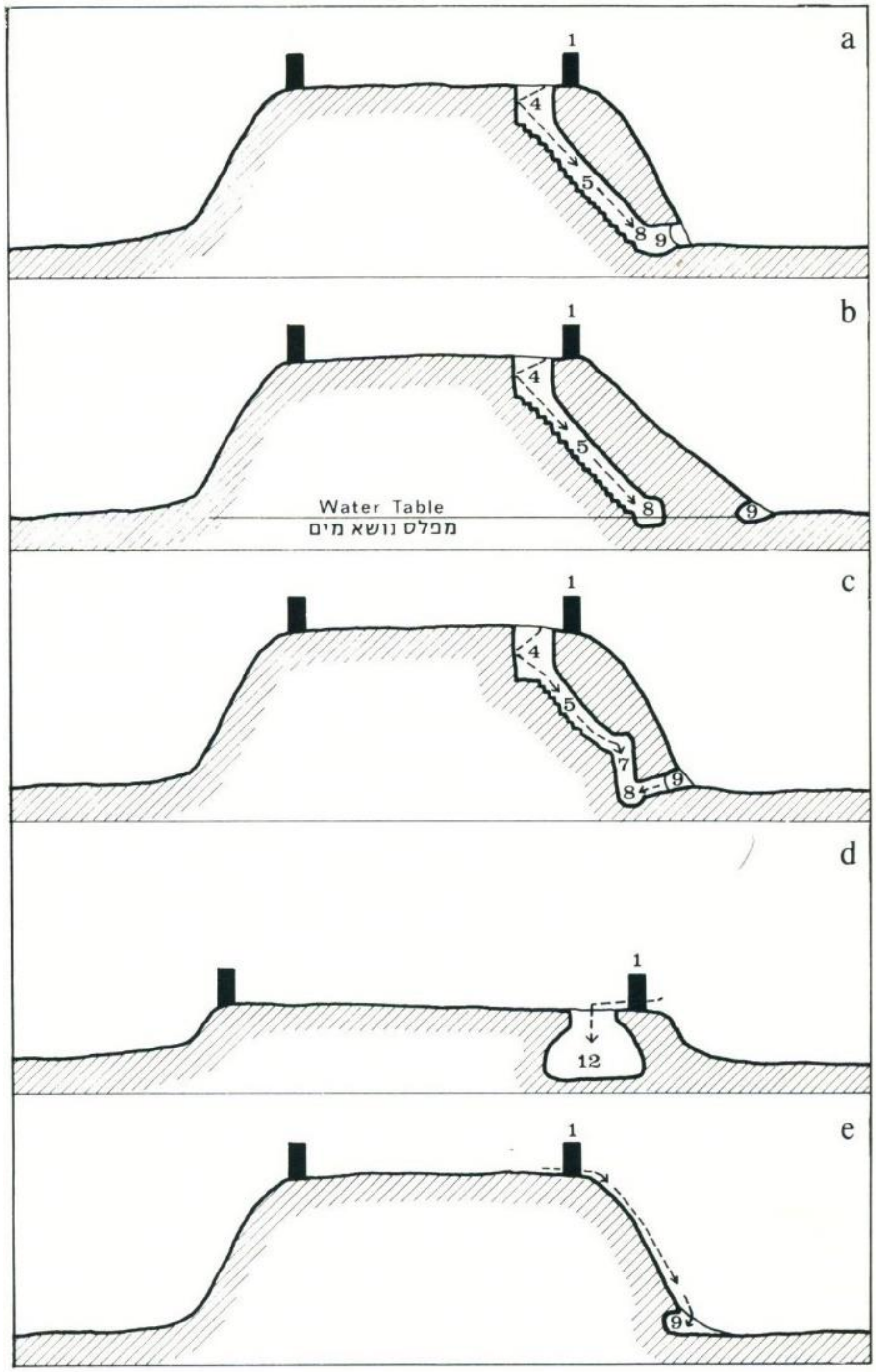

Figure 6 . This Scheme Indicates the Various Types of Water Systems of a Tall. (Shiloh 1992, 288).

In addition, Shiloh provides examples of water systems that were dated based upon in this method, such as Hazor, where the water system was ascribed to Stratum VIII, of the 9th century B.C. Gallery 629 at Megiddo served Strata VA-IVB, of the tenth century B.C., and the tunnel and the "pool" at Gibeon that began in the tenth century B.C. (Shiloh 1992, 291). Offering a similar approach, Cole argues that pottery and other objects found in water systems can provide an answer of when the water system went out of use, but not when it was originally constructed. The most reliable method to dating the construction of a water system is the "stratigraphy at the entrance to the system inside the city" (Cole 1980, 10). According to Cole, "it is a safe assumption that a shaft was cut after the latest stratum of the tall through which it cuts. This is not helpful, however, for dating a later system where ancient erosion has destroyed the uppermost strata" (Cole 1980, 10).

Another common water work present in the Middle East are water channels, also called earth channel or water conduits. Water channels can serve many purposes, such as watering gardens, irrigations on a small or even large scale as in Mesopotamia where channels were constructed to lead water from Tigris, and in Egypt (Oleson 1992, 889) when drawing water from the Nile was the main source to watering crops and livestock. Water channels (Figure 7) also could be used for draw water or to supply water to reservoirs or cisterns, either from a spring or by runoff from a rain. In places where erosion or porosity was a problem, channels were constructed with a line of stone labs. In order to provide a smooth flow of water and avoid leaking, they plastered it with limestone. An example of this type of channel was found in Tall Jalul. Following the abandonment of a site, the water system would suffer a process of disintegration.

Figure 7. A Water Channel in Qumran, Israel.

The process of disintegration of water systems can be seem as identical at many sites, and is characterized by “quantities of debris that fell into them, blocking tunnels and shafts” (Shiloh 1992, 291). The depressions above the ancient shafts would serve as spots to store rainwater and floodwater after the destruction as long as the city was occupied (Shiloh 1992, 291).

CHAPTER 2

THE WATER SYSTEM OF TALL JALUL

Water Channel

In 2007, two new fields were opened in Tall Jalul, Field G and H, both located on the south side of the tall. These fields were opened with the hope of locating a city wall. In Field G, a 3.0 meter stretch of a large stone wall was excavated in Square G2. The impression at that time was that this wall could be a part of a tower for city's fortification system (Younker, Gane, and Shqour 2007, 74-75). More excavation was needed in order to verify this supposition, and since the base was not reached, the exact date for this wall was uncertain. While excavating the north face of the wall described above, was found a plastered channel that seemed to drain water to the outside of the city wall. At that time, it was the impression that the channel seemed to cut into the earlier wall system, therefore not belonging to the same time period of the city wall. In addition, a wall with plaster was found in Square G4, north of the water channel, and it was suggested that it was probably associated with it. A second wall fragment was found further north and dates to the Late Iron II/Persian period (Younker, Gane, and Shqour 2007, 75).

Excavations in the water channel (Figure 8) continued in 2009, and in the 2010 season, work at the site continued for three weeks with the main goal of following the water channel and discovering its route.

Figure 8. The Water Channel of Tall Jalul Sloping to the City Exit.

Square G11 was opened in order to trace it, further work revealed the route. Preliminary readings of the pottery found under the foundation of the water channel indicate that it was constructed during the 7th century B.C., while the pottery found inside of the water channel on its floor suggests that it went out of use at the end of the 7th or in the beginning of the 6th century B.C. (Gregor 2009, 198). Nevertheless, it was not constructed after the destruction of the city walls and pillared building, based on the path of the channel and its exit outside the city wall.

The water channel was not constructed in a straight line from the water source to its exit, but its architecture was carefully navigated it in such a way that would bypass the 8th century B.C. building structures located in Field G leaving that intact (Gregor and Gregor 2010, 497).

The channel runs parallel with the reservoir toward the southern part of the city wall moving in a straight line, but after 20 meters it curves around structures almost parallel to that wall, cutting through the eastern section of the wall and exiting through the city wall in the corner where the eastern wall and southern wall meet.

According to measurements made in the channel, the elevation at both ends indicate that the highest point is where the bypasses the water reservoir (806.44 above sea level) while the lowest point is in the end which exists through the city wall (805.82 above sea level) (Gregor and Gregor 2010, 498). This led the excavators at the time of the measures to conclude that the function of the channel was not to feed the reservoir from another source. It was suggested that at times the water level was so high that the city dwellers had to get rid of excess water by building a channel to prevent flooding the city streets (Gregor and Gregor 2010, 498), maybe functioning as a gutter in order to remove the excess of water from the acropolis.

In order to construct the channel, the area where the channel would pass was carefully leveled by the ancient architects. Then they laid down the foundation and built its walls, building after that the channel. In addition, earth was brought to support the walls on the outside (Gregor and Gregor 2010, 498). The channel is well preserved, built with small and medium-sized boulder stones, and the channel found in the squares G2, G5, G11, W1, W3 and W4, is 0.5 meters wide throughout its excavated length (Gregor and Gregor 2010, 498) of about 50 meters. The inside walls of the channel and its floor were plastered. The walls were 0.3 meters thick and plastered on the inner sides, so it could provide better water flow. The walls of the channel are well preserved, but one side in the middle of the channel in the northernmost section is partially destroyed, probably by stone robbers in the antiquity. Also, the height of the walls can reach up to 1.5 meters at some places, which indicates that the volume of water that used to be in the reservoir in times of rain was very high. Concerning the floor of the channel, it was constructed with neatly placed flagstones covered with a thick layer of lime plaster (Gregor 2009, 198), allowing for a good water-flow. As mentioned previously, the lowest point of the water channel is located near its exit of the city wall, therefore, it would empty the excess water in the reservoir in times of rain, leading the water to the outside of the city. Since water in this particular arid region was a really rare article, it could not be wasted, so it is suggested that the remnant of water would go to open pools or reservoirs located bellow the Tall (Gane et al. 2010, 200). That, however, is only a suggestion, since the water channel does not connect to the water system, but passes the depression on its eastern ridge, going further north, and runs parallel to the reservoir, about 6 meters to its east.

At the same time, pottery found in the bottom of the reservoir indicates that they co-existed (Gregor, Ray, Younker, & Gane 2011, 361). Further excavations may bring new data and perhaps a definitive answer for this case.

Water Reservoir

In the 2010 season a decision was made to open a new field, Field W, in order to find the continuation of the water channel from Field G, since there was an expectation that it would run straight to the depression where the remains of a water system were expected to be found. Four squares were opened in Field W (W.1-W.4), and the continuation of the water channel was revealed, however, it turned out as stated above that, it does not connect to the reservoir, but the channel goes further north.

Four occupational phases were found in Field W. Each occupational phase will be introduced separately and the history of their excavations along with the features of the reservoir are going to be presented.

Occupational Phase 1 (10th Century B.C.)

Occupational Phase 1 is represented by the reservoir walls and its plastered floors which were probably constructed during the 10^{th} Century B.C. The date of the reservoir's construction was established during 2011 season and confirmed during 2012 season (Gregor et al. 2015). The floor of the reservoir sits on a bedrock made of lime plaster. According to the excavations, during its life span of four centuries the floor was plastered at least four times (Gregor et al. 2015). The plaster was hardened by adding crashed flint stone to its lime composition. It is also probable that the wall of the reservoir (Figure 9) was elevated throughout the same time, adding to reservoir's capacity (Gregor et al. 2015).

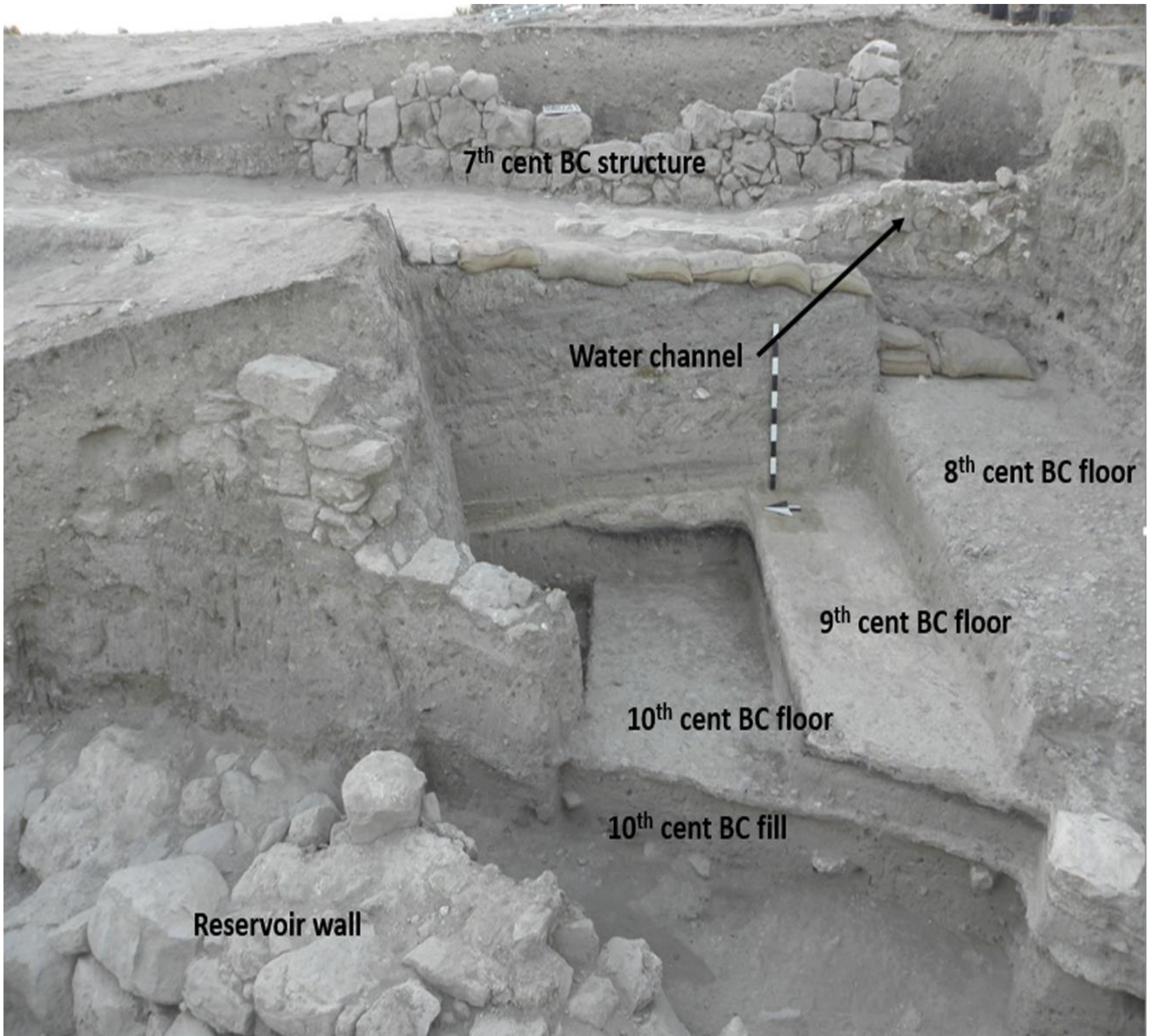

Figure 9. Different Occupational Phases in the Reservoir.

Occupational Phase 2 (9th Century B.C.)

Occupational Phase 2 was present in Squares W.2, W.5, and W.11 represented by floors and walls found outside of the reservoir but used in the same time period. The Floor W.2:25=W.11:21 was made of beaten earth and packed with pebbles, and built over a fill that represents an abandonment phase during the 10^{th} century B.C. (Gregor 2014, 167). The pottery found under this floor was mainly Iron Age I, with the presence of few Iron Age II shards. The floor was not leveled properly, therefore, it was covered with a fill and resurfaced again, creating a new floor W.2:23=W.11:17 which was made partially of lime plaster and beaten earth filled with pebble stones. On northern side of Square W.2 the fill was 0.5 meters high, while in the southern side of the same square revealed that the two floors joined being the same floor. Both floors were created in the 9th century B.C. and probably were surfaces such as walkaways or streets (Gregor 2014, 168).

Squares W.5, W.7 and W.11 also revealed in Phase II by the discovery of the water reservoir that was partially unearthed. The earth depression where the reservoir (Figure 10) was discovered measures more than 50 meters in diameter as its rim, therefore, Squares W.5, W.7 and W.11 only revealed a fraction of this feature (Gregor et al. 2011, 360). The wall (W.5:11=W.2:19=W.7:16=W.11:11) is 2 meters high and 1 meter thick at the rim (Gregor et al. 2011, 360). The inner wall is covered with several layers of plaster, which was also applied to its floor (Locus W.5:16). The plaster was made of lime mixed with finely crushed stones. It is compact, creating a hard surface which could have contained water for a long time.

According to the excavations, it is possible to see that the reservoir was re-plastered at least four times and its total thickness is 0.35 meters, but dates for replastering are not available since the plaster did not contain any dateable material (Gregor et al. 2011, 361). The first layer was placed either on the bedrock or a paved surface. At that point in time 12 meters of the reservoir's eastern wall (W.2:19=W.5:11=W.11:11) had been revealed, wall W.7:22 turns sharply, creating its southern perimeter (Gregor et al. 2012, 203). The southernmost section of the reservoir was also discovered in Square W.12:14. The upper section of the wall was removed throughout the years and only the

Figure 10. The Reservoir From an Inside Perspective.

plaster remains are visible today. Therefore, in order to preserve the plaster, excavation on the wall and the outside section of the reservoir was not continued, however excavation proceeded on the inside of the reservoir (Gregor et. al, forthcoming). According to the preliminary reports, it seems that the reservoir had an oval shape rather than a circular shape (Gregor et al. 2012, 203). Floors W.2:23, 25=W.11:17, 21 seem to have been sealed against the highest stones of the reservoir's wall, suggesting that these floors and the wall belong to the same phase. The pottery found in the bottom of the reservoir was not abundant, and included the remains of holemouth kraters, pythoi, cups and bowls dating to the Late Iron Age II (Gregor et al. 2011, 361). There is no evidence of destruction. Burnt material mixed with smashed vessels are totally absent, suggesting that this phase ended with a smooth transaction to the Phase 3.

Occupational Phase 3 (8th Century B.C.)

Occupational Phase 3 is found in Squares W.2, W.5 and W.11. It was found a small wall that is built on top of Floor W.2:23. However, due to stone robbing activities, only a fraction of this wall (W.2:12=28) survived, it continues into Square W.5 as locus 17, where it seems to be better preserved, and it is made of a single line of small stones lime that are 1.0 meters high and is located about 1.0 meters east of the reservoir, running along its rim (Gregor et al. 2011, 361). A fill of 0.6 meters thick was laid upon the Floor W.2:23=W.11=21 from the previous phase in some places, and a new floor (W.2:17=W.11:13) was constructed on top of the fill (Gregor et al. 2011, 361). "This floor was made of beaten earth, tightly packed, with pebble stones and sealed against the short wall (Wall W.2:12=28=W.5:17)" (Gregor et al. 2011, 361). The floor and the wall were used as a walkway or street, making the approach to the reservoir safer and more accessible.

Field W did not yield any burnt material to suggest that this phase ended violently. Suggestions are that the reason for this might be found in the fact that this was a water reservoir that was not attached to any domestic or administrative structures (Gregor et al. 2011, 361). (Figure 11) provides a good demonstration of the occupational phases 2 and 3.

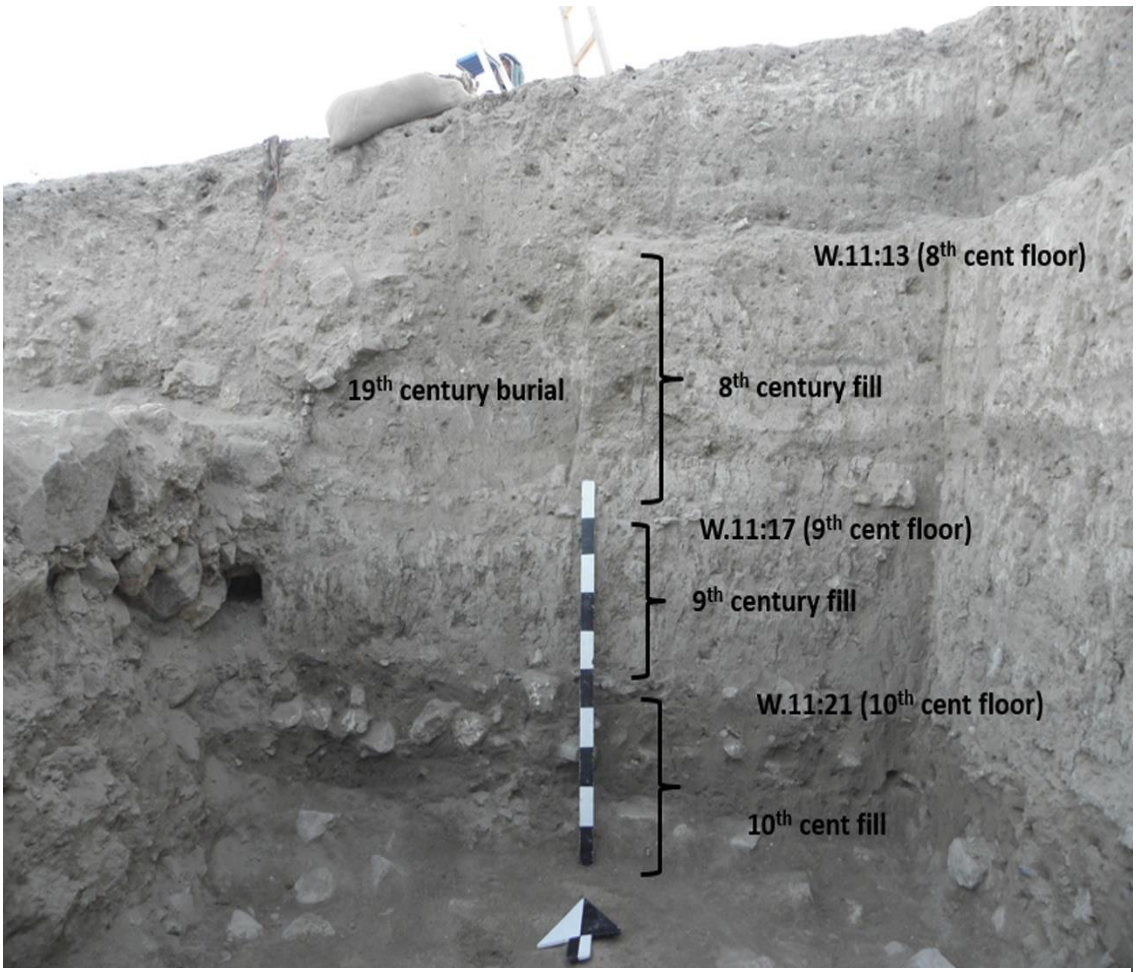

Figure 11. Occupational Phases in Detail From 10th to 8th Century B.C.

Occupational Phase 4 (7th Century B.C.)

As stated previously, excavation on the outside of the wall in the southernmost section was not continued in order to preserve the plaster. However, excavation continued on the inside of the reservoir. The excavation in Square W.7 was completed and the floor of the reservoir (W.7:27) was reached. Pottery shards consisting of bowls and jar fragments, were found on the floor dating to 7th century B.C. The floor of the reservoir was also reached in Squares W.8:15, W.9:14 and W.10:13, excavated during the 2014 season, with a similar pottery assemblage, and indicating that the reservoir went out of use during the 7th century B.C. (Paul Gregor, personal communication, October 13, 2016). The deepest section of the reservoir was found in Square W.9. Its northwestern corner has sudden dip of 20 centimeters within one meter, suggesting the possibility that the approach to the stairs for the reservoir may be located on its western side. Future excavations might bring new discoveries concerning the reservoir's stairs. Also on the southernmost section, a wall was found during the 2012 season in Wall.7:16 (Paul Gregor, personal communication, October 13, 2016). At that time excavation in this square was not completed and the wall's nature and function were not known. Although the 2015 season revealed the full scope of this wall, its function is still not completely clear, since it was built inside the reservoir at an angle. Another wall was found in Square W.8 located north of Square W.7, parallel to W.7:16. According to preliminary reports (Gregor et al. forthcoming) it seems that both walls (W.7:16 and W.8:16) were built at the same time and belong to the same structure. "The walls were not built against each other but to keep soil mixed with rocks between them. The structure is 5 meters wide at the base and it peaks at the top" (Gregor et al. forthcoming).

The Wall found in Square W.7 was built at a 42° angle and the wall in W.8 was straight, constructed from large partially hewn boulders, on the other hand, W.7:16 was constructed with smaller stones. The structure was built on the floor of the southern section of the reservoir and is attached to the reservoir's wall. According to the last preliminary report of Tall Jalul (Gregor et al. forthcoming), there seems to be another wall laid on the reservoir's found in Square W.10:12 which looked like stairs, built with a few large boulders with smaller chink stones. Its function will hopefully be clearer in future excavations once the eastern balk of Square W.10 is removed. These structures seem to be constructed during the same time, which was likely toward the end of reservoir's existence in the end of 7^{th} century B.C. After this occupational phase, the reservoir was no longer used and was filled with debris, a process that continued for many centuries. It was filled with material containing pottery from all periods dating from Persian to Late Islamic periods.

According to preliminary estimates (Gregor et al. forthcoming), the reservoir is approximately 20 meters wide, 30 meters long and 3 meters deep. It could have contained about 1800 cubic meters of water, which equals to almost half a million gallons, making it one of the largest opened air reservoirs constructed during the 10^{th} century B.C. in the entire region. The following Figures (12 - 15) provide more details and a better perspective about the water system of Tall Jalul.

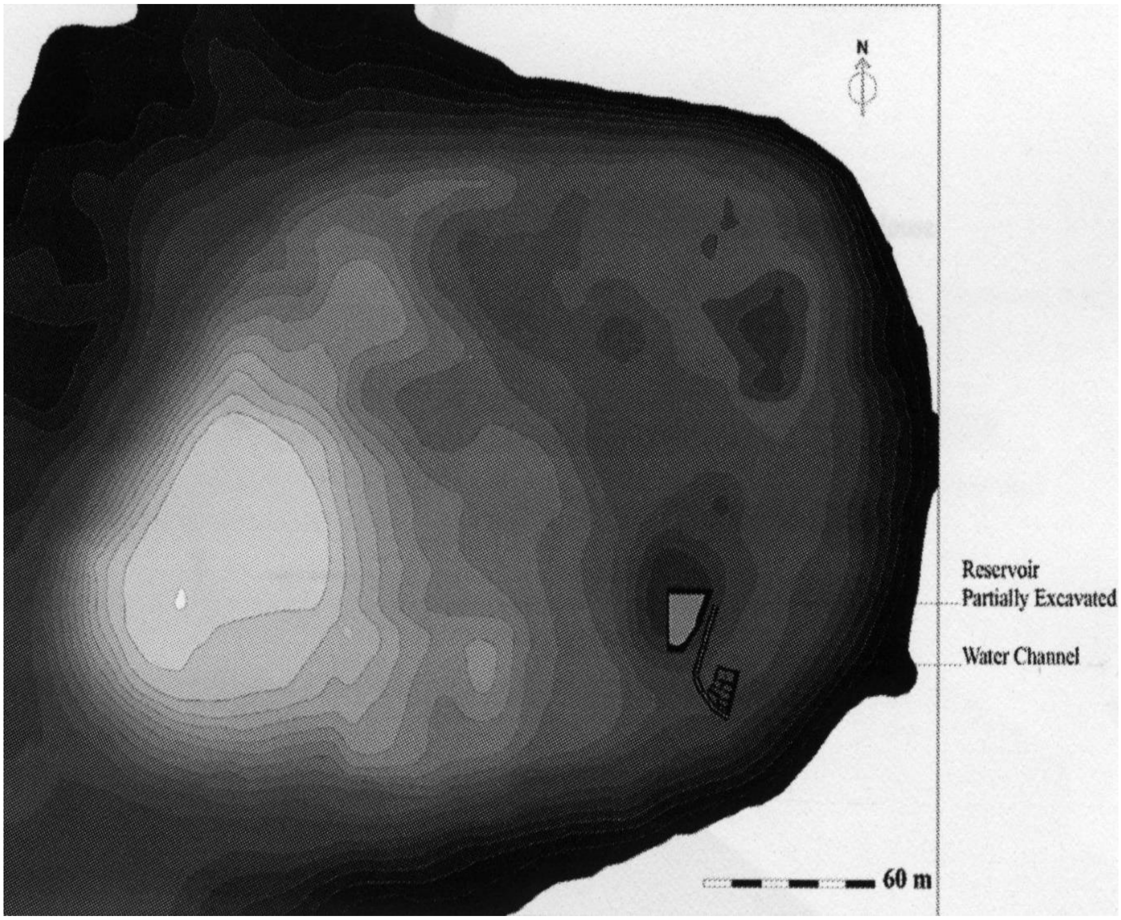

Figure 12. A Topographic Map of the Water System of Tall Jalul (Prestes 2014, 65).

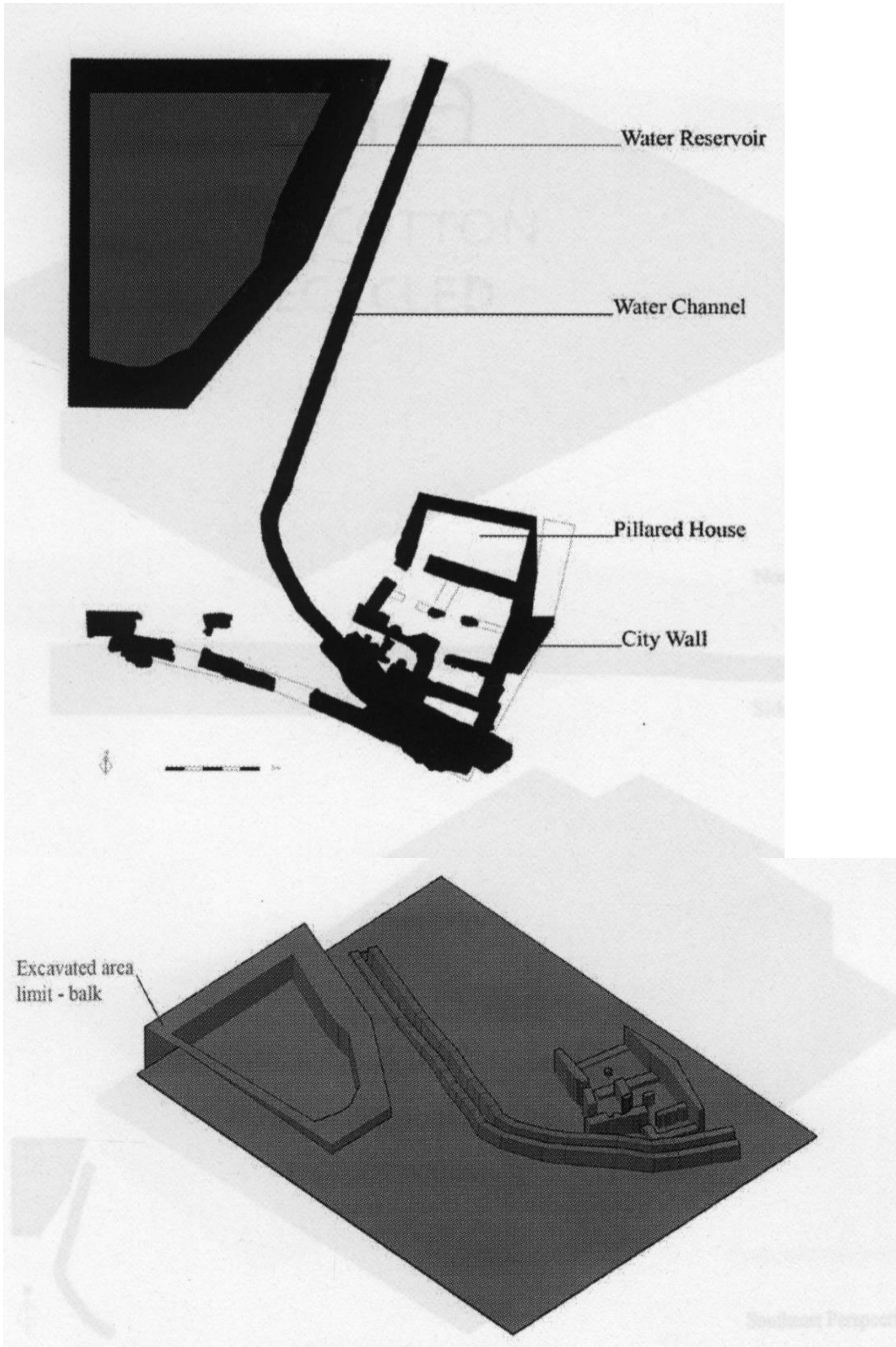

Figure 13. Fields G and W Water System Top Plan of the Season of 2014 (Prestes 2014, 66).

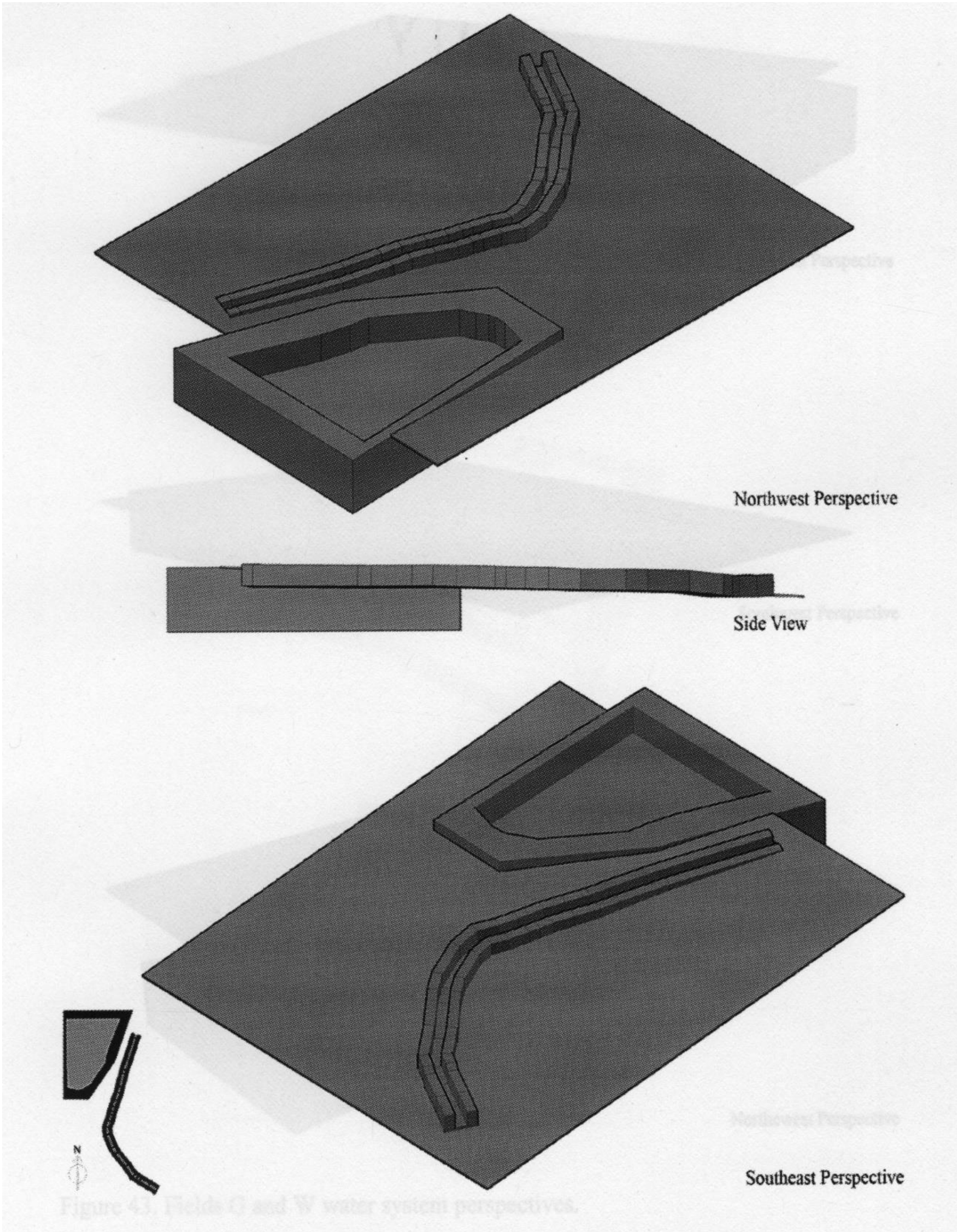

Figure 14. Isometric Perspectives of Water Systems of Tall Jalul (Prestes 2014, 67).

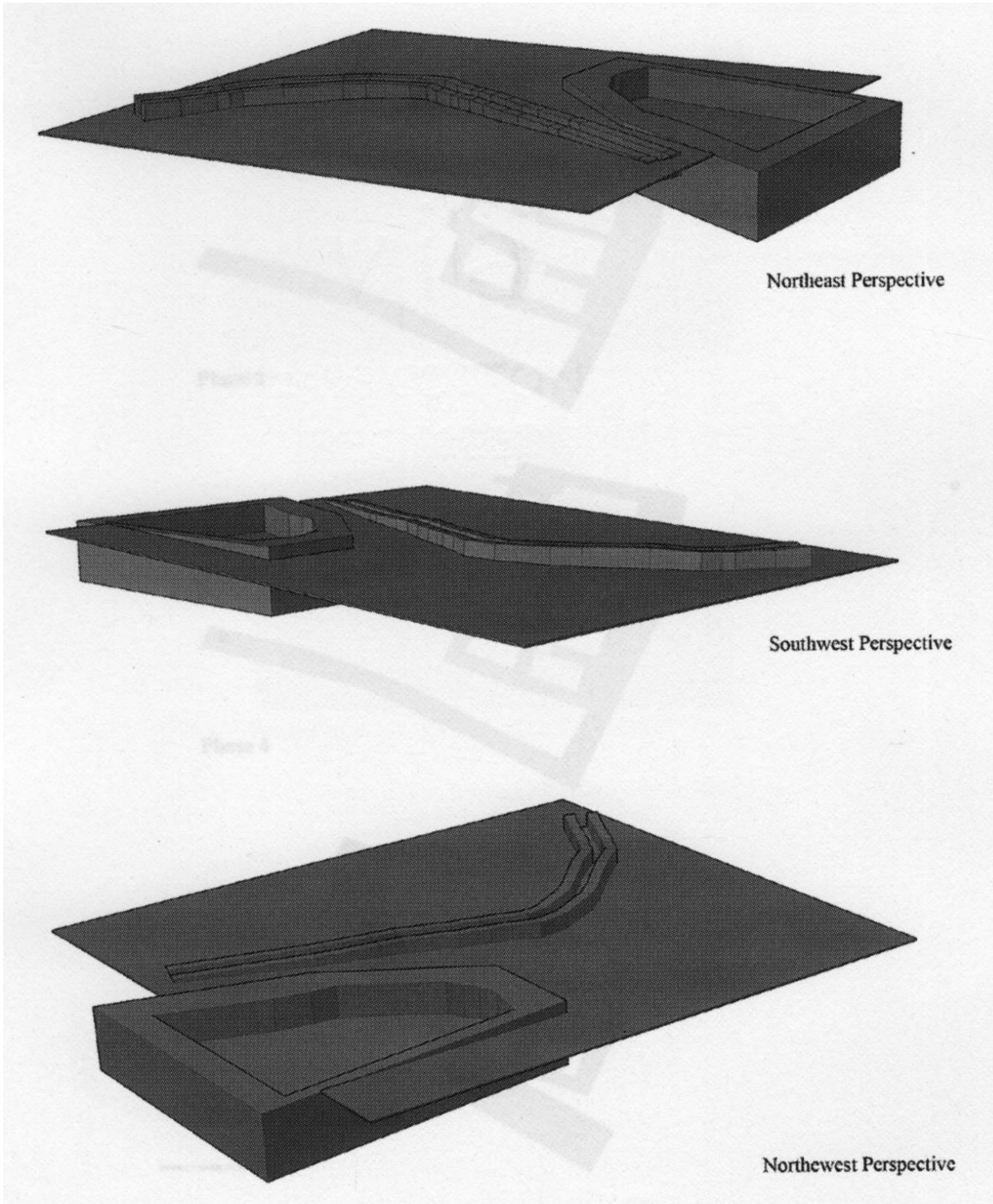

Figure 15. Tall Jalul Water System Perspectives (Prestes 2014, 68).

CHAPTER 3

IRON AGE WATER SYSTEMS IN PALESTINE

Warren's Shaft

The Gihon spring was the main source of water available in ancient Jerusalem, and since minor springs around the city were not enough to supply water to its inhabitants, solutions for this issue were found in the construction of reservoirs and cisterns, publics or private. Discovered by Charles Warren in 1867 in his expedition to Jerusalem, the shaft that carries his name is considered one of the earliest water systems in Jerusalem, consisting of four phases: (1) an entrance chamber; (2) a sloping tunnel; (3) a vertical shaft 14 meters high; (4) and a horizontal tunnel leading the water from the spring to the bottom of the shaft. Barkay describes the upper entrance to Warren's shaft to laying "inside the line of Iron Age walls, the same line as the Bronze Age walls" (Barkay 1994, 369). The engineers of this water system made use of a karstic vertical fissure in the bedrock. In order to reach the natural shaft located outside of the city walls, they started to hew inside of the city wall a horizontal tunnel, an underground passage that would reach the top of the natural shaft. This horizontal tunnel, however, was not part of the karstic fissure. A lower horizontal tunnel which connected to the Gihon spring would lead water until the bottom of the vertical shaft, where the inhabitants would use a rope and containers to have access to water. Scholars date the Warren's shaft (Figure 16)

Figure 16.Warren's Shaft Stepped Tunnel,
Jerusalem (Shiloh 1992, 285).

to Iron Age, however, before the time of the reign of Hezekiah because he had made use of the lower the lower horizontal tunnel to begin the tunnel that carries his name (Mazar 1992, 480-81). Shiloh, who has examined the system first hand, provides more details. The entrance of the shaft is hewn into the rock, descending about 8 meters to the beginning of the horizontal tunnel which is about 28 meters long and reaches the head of the vertical shaft. The vertical shaft descends 12.3 meters down to the level of the channel that connects the water from Gihon Spring. This channel connects the water from Gihon spring at a length of 22 meters.

Shiloh describes other features such as a vaulted chamber that protected the upper entrance area from silting and debris from the eastern slope which belonged to a later phase, and also an entry tunnel that was built within it, "connecting this later phase with the surface." According to Shiloh the additional shaft, that blocked the entrance to the cave, which has all natural karstic clefts and shafts, were utilized and integrated into the water system (Shiloh 1992, 284-85). Although the traditional position that Warren's shaft was indeed used to draw water, new studies conducted by Reich and Shukron who carried excavations in the site in the 1990's challenge this position. They concluded that the shaft was not exposed or discovered until 800 B.C., and that the Warren's shaft was not used to draw water. According to Reich and Sukron, the inconvenient shape of the shaft formed by karstic action of dripping water "filled with protrusions that make it very difficult to lower and lift a bucket" (Reich and Shukron 1999, 33). Another point is that the bottom of the shaft according to Reich and Shukron "was not deep enough to allow a bucket dropped from above to sink conveniently into the water and be filled (Reich and Shukron 1999, 33).

Hezekiah's Tunnel

The purpose of Hezekiah's tunnel (Figure 17) was to lead all the water from Gihon Spring through an underground tunnel to Tyropoeon Valley, located on the opposite side of the Iron Age Jerusalem, which in Hezekiah's time was also located inside of the city (A. Mazar 1992, 483), securing the city of Jerusalem with water against enemy sieges.

The tunnel was discovered by E. Robinson in 1838, and later explored by Charles Warren and Piere H. Vincent. The tunnel has a length of 533 meters beginning in the spring and going all the way until the Siloam Pool According to an expedition performed by

Figure 17. Inside View of Hezekiah's Tunnel, Jerusalem.

Shiloh, the difference in height between the beginning of the channel at the spring and the end of the tunnel is only about 30 cm Shiloh (1992, 285). The average height of the tunnel is around two meters, reaching five meters at its southern end. The southern end of Siloam channel was utilized as an overflow channel for the Hezekiah’s tunnel. At its upper end, Hezekiah’s tunnel utilizes the connecting tunnel running between the spring and the bottom of Warren’s Shaft.

The tunnel runs in S-shaped curves under the ridge of the city of David. Another feature regarding the tunnel is its hewing process, since the tunnel was cut without vertical shafts, making the work very difficult due to air and light deficiency (Mazar 1992, 484). The work was carried by two groups of workers, starting from opposite ends and meeting each other at a certain point of the tunnel. The moment when the two groups met was recorded in an Hebrew inscription known as “Siloam inscription” as follows: and this was the mater of the tunnel: While [the hewers wielded] the axe(s), each man towards his fellow, and while there were still three cubits to be he[wn, there was hear]d a man’s voice calling his fellow; for there was a fissure (?) in the rock on the right and [on the left]. And on the day it was tunneled through, the hewers struck [the rock], each man towards his fellow, axe against axe. And the water flowed from the spring towards the pool for one thousand and two hundred cubits. And a hundred cubits was the height of the rock above the head(s) of the hewers (ANET, 321). The length of the entire project was 643 meters, or almost 1200 cubits, as attested in the Siloam inscription.

The Hezekiah’s Tunnel was excavated through limestones. In the region of Jerusalem, the formation of rocks is generally thickly bedded, dipping toward the southeast and karstified (Frumkin and Shimron 2006, 228). The floor, part of the walls, and ceiling are covered by secondary materials, both man-made and natural, and are important for dating. Plaster was applied on the floors and walls of the tunnel until chest height, sealing against water loss through fissures and karst voids. Fissures above the tunnel allow dripping water into segments of the tunnel. Four varieties of plaster were found in Hezekiah’s tunnel, each one with chemical and petrographic characteristics. The ancient plaster [the oldest one] is a very fine grained hydraulic plaster composed mainly of a mixture of finely crushed filler materials including soil aggregates, chips of marl and crushed bones, as well as small amounts of charcoal and ceramic shards (Frumkin and Shimron 2006, 230). The second kind of plaster is the red plaster and mortar, it is composed of red pottery chips and lesser amounts of rock chips. Woods ash was additionally added as filler material into this plaster. It is present in the southern exit of the tunnel and part of one of the blocking walls east of Gihon Spring. The amount of pottery shards indicates that the plaster belongs to the Byzantine period (Frumkin and Shimron 2006, 231). The third kind of plaster is the grey plaster and mortar which overlies the ancient plaster. It is dark colored and has a coarse fabric due to the addition of coarse filler materials, being found covering the ancient plaster close to the Gihon Spring. According to Carbon 14 dating, this plaster can be ascribed to the Mamluk period (Frumkin and Shimron 2006, 231).

Finally, it was also attested that there was presence of black plaster. It is composed of very fine grain, containing materials such as slag, ash and other organic materials. This plaster was applied by the Parker-Vincent expedition, when they completed their work in the tunnels. It is found in the construction material of the blocking walls which cut off the base of Warren's Shaft from Hezekiah's tunnel and two nearby channels (Frumkin and Shimron 2006, 231). The ancient plaster and overlying plasters are covered by a continuous ca 2-4 centimeters thick lamina of naturally deposited geological materials. They were deposited from water flowing along Hezekiah's tunnel, being deposited above the ancient plaster, and it seems to be an indication that the oldest plaster was applied soon after the completion of the tunnel. Frunmkin and Shimron (2006) have discovered well-preserved organic materials in the ancient plaster, and subsequently together with speleothems, were able to radiometrically constrain Hezekiah's tunnel age. The calibrated carbon 14 age of organic materials found in the ancient plaster dates of 822-796 B.C. for a piece of wood and two ranges of 790-760 and 690-540 B.C. for a short lived plant. These materials were incorporated into the plaster and must have lived before the Hezekiah's tunnel construction. The date constrains the age of the tunnel well within the Iron Age II, an age that is also sustained by the paleography and philology of the Siloam inscription (Frumkin and Shimron 2006, 232).

The Water System at Gibeon

The Iron Age water system at Gibeon provided the inhabitants of the city with access to water within the city walls. It was designed primarily to provide water in times of siege, but at the same time it provided a more convenient way to access water for its population. In summary, it consisted of a stepped tunnel cut through the rock of the hill, located inside of the city walls, which gives access to a horizontal tunnel that leads into the spring. A Pool and stairway cut in solid rock also gave access to water from within the fortifications.

Sometime after the construction of the Iron Age city wall, a stepped tunnel was made through the limestone rock of the hill to connect the spring that issues from the lower part of the hill outside of the city walls. In this way, water would be available for the inhabitants when it was "shut up" in times of siege. The whole engineering project involved the cutting of the cistern room, the horizontal tunnel leading to the spring, and the stepped tunnel (Pritchard 1961, 2).

Description of the Water System

According to Pritchard, the construction of the cistern room (Figure 18) started where the spring issues from the base of the hill. There, an opening measuring 2.60 m wide and 1.50 m high was cut. The roof of the cistern is horizontal, and the floor declines toward the back until the room reaches a height of 3.0 m at the south end. The width of the room remains the same of about 6.0 m from the opening and enlarges to the left and to the right to about 8.0 meters (Pritchard 1961, 3).

Figure 18. The Cistern Room, Gibeon (Pritchard 1961).

According to Pritchard, for someone coming from the outside into the cistern room, a deep groove of about one meter long located on the west wall, was cut horizontally into the wall about one meter above the floor. The room steps down about 0.35 m on to a flat surface which extends about one meter to the south. A groove of 0.35 m wide cut into the floor and a corresponding groove of 0.75 m appears in the western wall and extends to the roof (Pritchard 1961, 3). According to Pritchard, the grooves in the floor and walls were made to secure the barricade or door, which served to keep an enemy from accessing the spring water and into the city (Pritchard 1961, 3). A water channel was constructed in order to conduct the overflow of water from the cistern to the outside. This water channel had a double purpose. It served to make fresh water available outside without waiting for the cistern room to fill and overflow when a small quantity of water flowed. When the opposite occurred, the segment of the channel at the doorway served to take care of the overflow from the cistern room (Pritchard 1961, 4). A horizontal tunnel (Figure 19) connects the cistern room with the spring. The length of the tunnel is 34 meters and it has a water channel cut into its floor to conduct the water from the spring to the cistern room. The purpose of this water channel was to increase the flow of the water at the time it was in use (Pritchard 1961, 4).

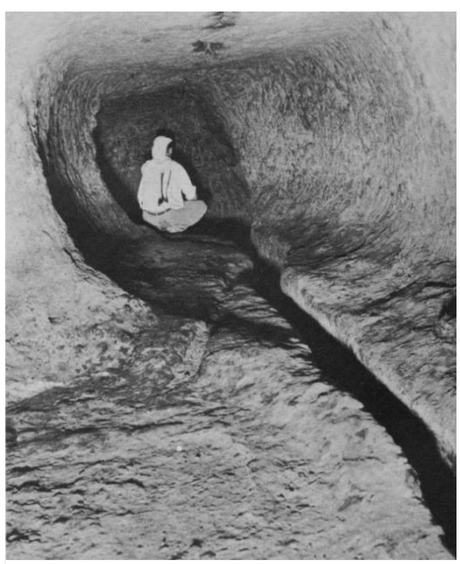

Figure 19. The Horizontal Tunnel, Gibeon (Pritchard 1961).

Figure 20. Stepped Tunnel Looking From the Cistern Room (Pritchard 1961).

The stepped tunnel (Figure 20) gives access to the cistern room. It begins at the northeast corner of the cistern room and leads to an upper opening 2.40 m to the south of the inside face of the city wall. The winding course length of this tunnel measures approximately 45 m in a horizontal plane. The drop in elevation of this tunnel is 24.60 m. The incline of the steps is uneven and the actual measurement from the top to the bottom step is approximately 52 meters (Pritchard 1961, 5).

Pritchard divides the stepped tunnel in five segments, A-E. Segment A consists of the steps 1-25 from the floor of cistern room to the first bend in the tunnel. The horizontal length of the segment is 10.60 m. Seven steps lead up from the floor of the cistern room to the round-shaped opening in the roof. Suggestions are that five of six steps were covered by water when it was filled (Pritchard 1961, 5).

Segment B comprises the steps 26-47 with a horizontal distance of 10 m. It was cut through the solid rock of the hill. The tunnel makes a sharp turn to the right, beginning at step 26 and continues to the southwest (Pritchard 1961, 6).

Segment C comprises of steps 48-70, having a horizontal distance of 11 meters. It consisted of a trench cut from the surface of the hill and covered over with large stones and soil (Pritchard 1961, 6).

Segment D comprises of steps 71-82, having a horizontal length of 7.40 m. Tunneling rather than trenching was resorted to in this segment, there is a 2 meters support between the roof and the base of the city wall above. This segment ends at about the middle of the inner phase of the city wall (Pritchard 1961, 7).

Finally, Segment E comprises of steps 83-93, having a horizontal length of 6 m, and according to Pritchard it consists of a roofed section in line with the tunnel below it and the entranceway which turns 90 degrees to the left as it opens into the city (Pritchard 1961, 7). Since the debris that filled the tunnel had been washing down for centuries, dating the construction of the tunnel is difficult without reliable evidence. However, according to Pritchard, it is evident that the tunnel was cut after the construction of the Iron Age II city wall. Also apparent from the general plan is the fact that the tunnel was cut after the construction of the pool of Gibeon. It is, therefore, likely that the tunnel belongs to the Iron II period (900-600 B.C.), and probably to the latter part of it, to judge from the pottery associated with the foundation of the city wall (Pritchard 1956, 73, 75).

The Pool of Gibeon (Figure 21) was cut in a circular shape, having a diameter of 12.30 m (N – S) to 10-30 m on the E-W axis, the depth of the cylindrical portion of the pool is 10.80 m below the highest point of the rim. The pool contains a circular stairway, which consists of 40 steps of uniform size. The first three steps from the top are constructed of well-cut stones, while the remainder are cut from the live rock of the hill (Pritchard 1961, 8). The debris found inside of the pool contained pottery no later than Iron Age II period. Therefore, it is likely that the pool had fallen into disuse around the 6^{th} century B.C. (Pritchard 1956, 69). Its purpose is not clear, no evidence of plaster on the walls were found; neither openings along the rim for a channel nor other conduits to supply it with rain waters were found. Pritchard argues that the so-called pool is actually a stairwell cut into the living rock of the hill in order to reach the water table (Pritchard 1961, 9). The most plausible explanation given by Pritchard (1961, 10) for the construction is that the ambitious beginning in the construction of the pool was reduced, maybe by social and political changes, which could have reduced the costs, therefore, making the final work less spectacular by the process of tunneling.

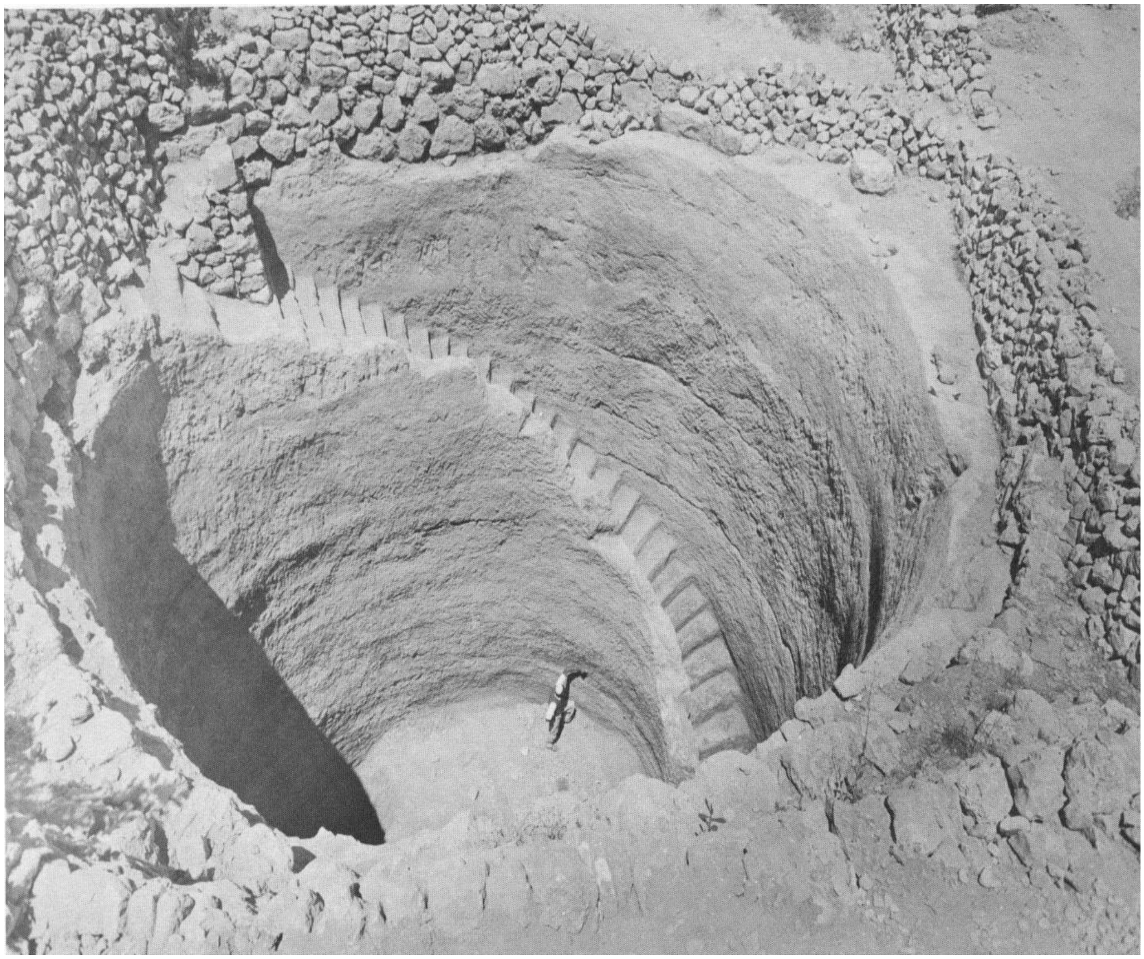

Figure 21. Pool of Gibeon (Pritchard 1961).

The Water System at Qumran

The Iron Age water system at Qumran is not well developed in size and features compared to later periods of the site. It is basically constituted of one round cistern (Figure 22) and a water channel that is considered by many scholars to belong to the Hasmonean period, while scholars such as Cross and Milik (1956, 6-14) defend the conclusion of it belonging to the Iron Age.

Figure 22. Iron Age Round Cistern at Qumran, Israel (Hidiroglou 2000, 139).

The earliest settlement at Qumran was established during the 8th and 7th century B.C. A round cistern dating of this period was excavated. It was filled during the rainy season by runoff water coming from the esplanade to the north of the settlement, and its capacity is around 125,000 L (Wood 1994, 46). The cistern remained in use until the destruction of the settlement in Iron Age II, although it was also used in later periods along with other cisterns.

Nonetheless, having the water channel existing during the Iron Age helped to supply the cisterns with water coming from a gorge between two cascades about twenty meters high. The aqueduct is about 800 m long, and is bordered and covered with flat stones (Hidiroglou and Grenache 2000, 138-139).

The Water System at Hazor

The water system at Hazor (Figure 23) it is one of the largest of its type, being twice the size of the one found in Megiddo. It was discovered by Yagael Yadin in 1967, who dated the water system to the 9th century B.C. (Yadin 1969, 63).

The water system consists of three elements: (1) the vertical shaft; (2) the tunnel; and (3) the entrance structure to the shaft. The shaft is composed of two parts, an upper segment cut through the strata of the mound and the lower segment quarried out of the rock. Measurements of the upper segment are nineteen meters from west to east and fifteen meters from south to north (62 by 49 feet). Its depth, from the top of the mound where the altitude is 232 m above sea level, is about 10 m or 33 feet (Yadin 1969, 66). Supporting walls up to a height of four meters revetted this part, especially on the south and west sides; the walls were built on a ledge cut in the bedrock.

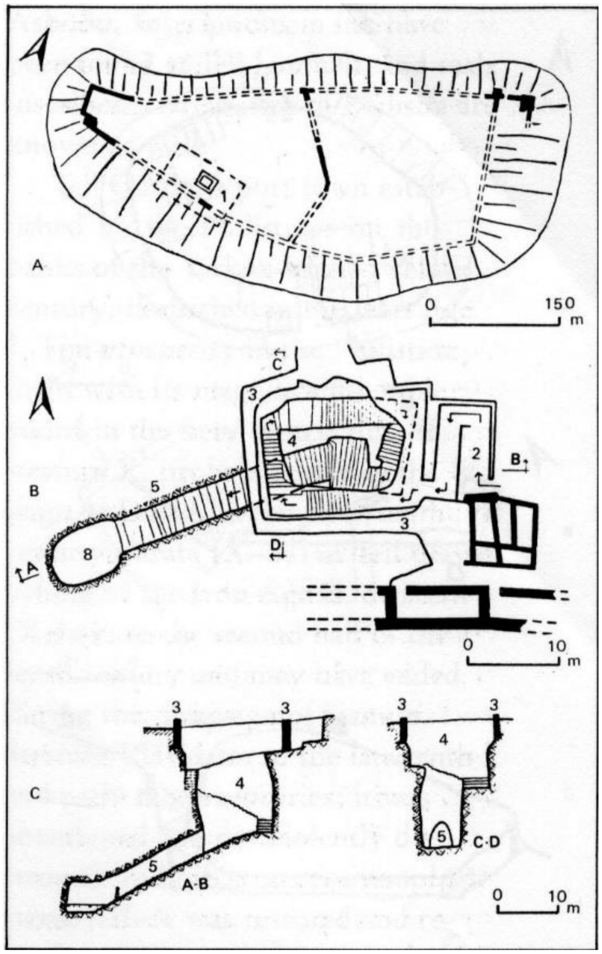

Figure 23. The Water System Plan of Hazor;
Location, Plan and Sections (Barkay 1992)

The depth of the shaft (Figure 24) is about thirty meters, with the measurements of the hewn shaft decreasing as it goes from the upper part to the bottom.

In order to reach the lower part of the shaft, the inhabitants built a rock-cut staircase, which is three meters wide. It begins on the southern wall, going to the west wall, north and east walls respectively. The second turn of the staircase takes the whole width of the shaft until they merge with the staircase of the tunnel. Yadin suggests that the exaggerated width of the stairs is related to the drawing of water by pack animals (Yadin 1969, 66).

Figure 24. An Aerial View of Hazor Water Shaft (Yagael Yadin, Excavation at Hazor, 1968-1969: Preliminary Communiqué, Israel Exploration Journal 19: 1-19).

According to Yadin's observation, a large building connected with the casemate wall, Solomonic 10-9th century B.C. in date, is cut by the shaft of the water system. The pottery found in the bottom of the shaft suggests the abandonment during the 8th century B.C. The tunnel entrance is located on the west side of the shaft, and "it continues in a west-southwest direction for about twenty-five meters (82 feet) and its stairs incline about ten meters (33 feet), which means that the lowest point of the water system is just about 190 m of sea level, the same level of the springs south of the mound" (Yadin 1969, 66). The tunnel was cut with broad and narrow chisels, and it's a pointed convex. Both the height and width measure four meters. The entrance structure was planned to minimize the slope from the level of the city to the top of the quarried shaft, and at the same time connect the city with the stairway, going down around the rock-hewn shaft to the tunnel. Yadin describes the arrival at the water chamber. According to Yadin, the builders encountered a large bottle-shaped cistern of an earlier period. The builders cut its neck and filled up to the top. Yadin states that this fact was crucial to determine the date of construction of the water system since many intact vessels from the Late Bronze Age were found (Yadin 1969, 68).

The huge amount of sherds and vessels found in the debris in the depth of the shaft, indicate that it existed until the 8th century B.C. The trench cut by Yadin's team clarified the general stratification and determined the upper most stratum. Excavation at the trench, particularly in the south section revealed that the earliest date which the building of the water system can be attributed to the first half of the 9th century B.C. Yadin relates it to Stratum VIII, a period when the whole tall of Hazor was rebuilt and refortified (Yadin 1969, 68-70). Yadin highlighted the fact that the sloping tunnel was constructed in a west-southwest direction while the expectations would be for them to dig in the southern direction, where the springs were located (Yadin 1969, 66-67). Weinberger, Sneh and Shalev on other hand, hold a different interpretation regarding the knowledge of the builders and the location of the water system based on a hydrological and geological study. Weinberger, Sneh and Shalev point out that if the engineers dug toward the aquifer, they should have located the vertical shaft and saved a lot of time and work, since the location of the shaft, close to the southern edge of the mound, was clearly intentional (Weinberger, Sneh, and Shalev 2008, 3038).

In comparing the water system of Hazor with other Iron Age water systems in Israel, Weinberger, Sneh and Shalev reinforce the traditional knowledge that they were located nearby a water source at the foot of the mound. However, regarding the direction chosen by the builders, Weinberger, Sneh and Shalev states that: "this direction was apparently chosen to avoid digging too close to the outer face of the mound, notwithstanding the greater distance. A horizontal tunnel should have been designed to connect the end of the sloping tunnel with the springs. However, groundwater was encountered when they reached the fault zone at approximate 195 m above m.s.l. and such a tunnel became redundant. The water chamber was set up exactly along this zone, utilizing the westernmost fault plane as the edge of the chamber" (Weinberger, Sneh, and Shalev 2008, 3041). The original plan at Hazor was to reach the nearby springs, but Weinberger, Sneh and Shalev argued that by "luck coincidence" strands of the Dead Sea fault brought water into the city's perimeter, and that also would imply limited hydrogeological knowledge by its inhabitants at the beginning of the first millennium B.C. (Weinberger, Sneh, and Shalev 2008, 3041).

The Water System at Megiddo

The water system at Megiddo started to be seriously excavated by a team led by Lamon from the University of Chicago in the 1930s. This water system is one of the largest in Palestine and remains as one of the best examples of sophisticated engineered projects during Iron Age.

The water system comprises some caves. The “main cave has rock-cut steps leading down to a well (1074), was in existence long before the tunnel (1000) was constructed” (Lamon 1935, 5), and it was only accessible from the foot of the mound where the tall is located today, having its entrance exposed and not being safe during siege and war. During the Iron Age, however, an attempt to connect the mouth of the cave and make the well accessible within the city was made by the inhabitants by way of a small passageway also called gallery by Lamon (1935).

The gallery (Figure 25) was built of part ashlar and part rubble masonry and it is floored with large, fairly well squared flagstones. Lamon suggests that the gallery was “originally roofed over and buried forming a tunnel or gallery some 2 meters high and slightly more than a meter wide” (Lamon 1935,10). The gallery was found below the foundations of the 10^{th} century B.C. city wall. Although no pottery or other datable material was found in the gallery, Lamon argues that once the purpose of the gallery was to give access to the mouth of the cave, which in its upper part had a guard’s post, having material dating as late as the 12^{th} century B.C., that according to Lamon was constructed during the period when the gallery was still in function, therefore proposing a 12^{th} century B.C. date (Lamon 1935, 12). The gallery remained in use for a short period of time and although it “had temporarily solved the problem of concealing the entrance to the cave and making the well accessible only from within the city, it apparently was not entirely satisfactory” (Lamon 1935, 12).

A far more complexed water system was built later, also within the city, but providing better protection and mobility for the inhabitants. For that purpose, a well

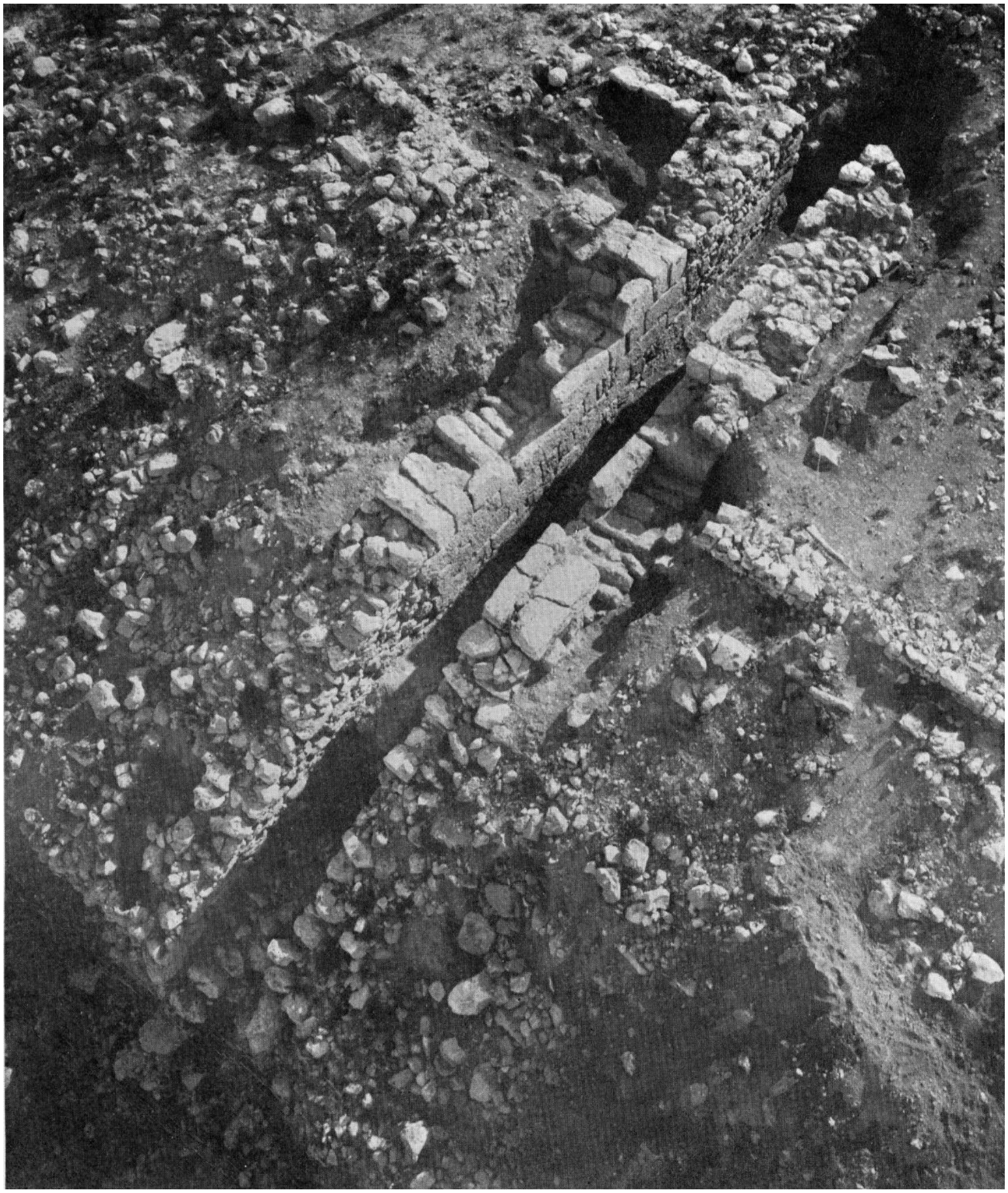

Figure 25. The Gallery at Megido (Lamon 1935, 11).

elaborated shaft (Figure 26) was designed to reach the level of the lower part of the main cave and then "connect the bottom of the shaft with the cave by a horizontal tunnel" (Lamon 1935, 13). What began as an irregular hole and reached the bedrock was improved later by the builders the builders as they built thick retaining walls, leaving a roughly square shaft. A staircase also was built along the inner side of the walls leading all the way down to the bottom of the shaft, but 10 m short of the depth of the well. What follows is a sloping shaft or inclined tunnel with masonry steps replacing the original rock-cut steps (Lamon 1935, 17). Later a correction had to be done, since, according to Lamon, the sounding tunnel that "originating at the bottom of the inclined tunnel, made an intersection with the cave at a point too high and too far to the south, a total error of about a meter" (Lamon 1935, 17). For that reason, the tunnel was enlarged downward and to the north. "When the sounding tunnel had penetrated to a certain point, a tunnel was started from the cave, and the work was carried on simultaneously from both ends" (Lamon 1935, 17-18). Once the tunnel was finished, it was decided to lower the floor, making an underground canal that would lead water from the well to flow to the bottom of the shaft, therefore making easier the access for the population. A blocking wall was built not much longer after the construction of the tunnel and it blocks the outside entrance of the cave. It is of crudely coursed stone masonry, consisted of enormous size boulders (Lamon 1935, 23).

The Eastern Tunnel is a later addiction into the tunnel, and was planned to be an extension of the horizontal tunnel in an eastward direction under the steps of the inclined tunnel and then continues to the vertical shaft down to meet the end of the eastern extension. Lamon suggests that apparently the idea was to bring the water from the canal

Figure 26. The Shaft While in Excavation by Lamon's Team at Megiddo (Lamon 1935, 13).

into a sump at the bottom of the vertical shaft, and in that way water could be drawn by jars using a rope, such as is performed in a well.

Although a mistake in the length's calculation was made, the project was completed. Lamon dates the water system project to the 12th century B.C. and the Eastern Tunnel (Figure 27) to the 11th century B.C. An additional water system was discovered by Yagael Yadin's team. It is a staircase under the city gates that was discovered by the

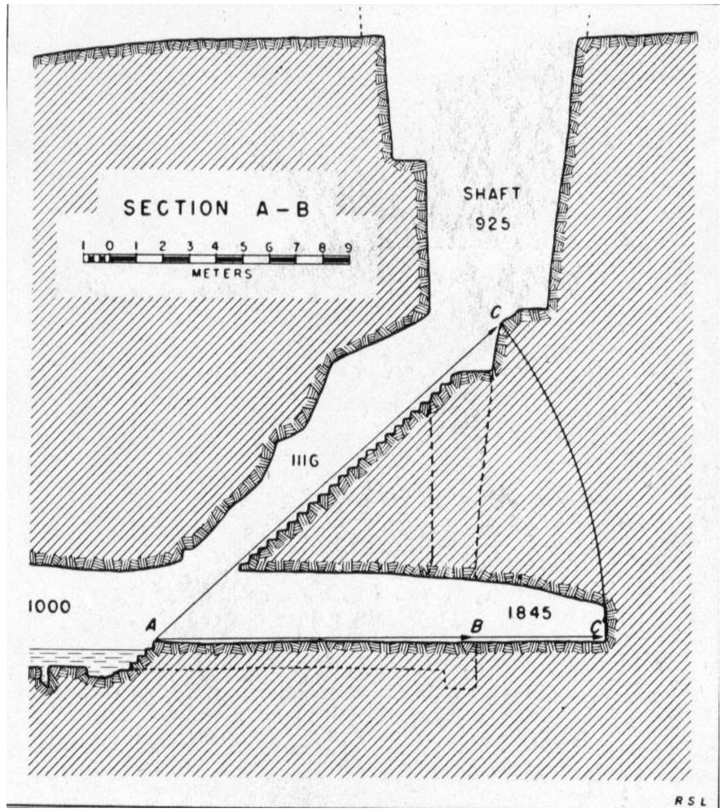

Figure 27. Draw Showing the Eastern Tunnel 1845 and the Inclined Passage at Megiddo (Lamon 1935, 29).

previous team, but the excavation was left incomplete. The excavators, with few evidence, reported that the stairs were probably part of a pedestrian approach.

The new excavations were able to reveal the continuation of the stairs turning east at a right angle towards a well plastered pool. This water system was dated to the 9th century B.C. (Yadin 1970, 93).

The Water System at Heshbon

In 1973, excavations conducted by Siegfried Horn from Andrews University revealed the bottom floor and part of the eastern wall of a 7 meter deep open air reservoir of the Iron Age at Tall Hesban (Horn 1982). This open air reservoir (Figure 28) or pool was nearly square with 17.5 meters on a side, covering an estimated 3,250 square ft. A section of the eastern face of the reservoir was a 5.75 m long and ca. 1.20 m thick wall of ashlar masonry (Ray 2001, 99). Sauer at first dated the construction of the reservoir to the 9th/7th century B.C. based on a few sherds discovered behind the eastern retaining wall, (1975, 165; 1976: 60), and attributed it to Stratum 17. Later, however, Sauer reevaluated the dating of the reservoir and suggested that it was built in the tenth century B.C., Iron Age IC/IIA (Sauer 1994, 241-44), placing the reservoir in Stratum 18. This reevaluation is supported by Herr (1997, 150; 1999, 227) and Ray (2001: 107). According to measurements it could hold about 2,200,000 liters or 500,000 gallons of water (Horn 1982, 22). The floor of the open air reservoir was covered by three layers of plaster, as strong as cement, and with a total thickness of about one foot laid on bedrock (Horn 1982, 22). The location of the reservoir near of the top of the mound has raised questions concerning its filling. The area of the mound above the reservoir amounts 4,500 sq. m. and the average annual rainfall is about 400 mm. which could produce one million liters, only half of the amount to fill the pool, not counting other situations such as evaporation, collection of water in other cisterns and pools. Horn suggests that it must have been filled by a large train of donkeys, served a military purpose and providing water for a fortress under siege (Horn 1982, 23).

Figure 28. Ashlar Wall in the Eastern Face of the Reservoir at Hesban (Ray 2001, 101).

During 1974 and 1976, what was believed to be channel was discovered in an Iron Age I stratum. It is ca. 1.5-2.5 meters wide, ca. 4.0 meters deep, and ca. 13.0 meters long. However, no cistern or reservoir was found in association with this channel. It was suggested that later digging into bedrock removed traces of an earlier cistern, and it also could have been related with some type of water storage (Merling 1994, 213). Estimations are that the size of the channel seems to have been ca. 065 meters wide and ca. 0.55 meters in depth (Sauer 1976, 58). Ray (2001, 88-90), however, has a different interpretation regarding this structure, suggesting that "two factors mitigate against the suggestion that the bedrock trench was designed as water channel. First, there was an easier route for channeling of water available only a short distance away. Second, the trench's width and depth would suggest that another solution needs to be reached" (Ray 2001, 89). He believes that this structure could possibly be a dry moat (Ray 2001, 90; 99).

In addition to the reservoir, there is a plastered pool in Tall Hesban. This pool is 1.5 meters deep with a diameter of 4-5 meters and gradually sloping sides. It could hold 2,530 liters of water (Merling 1994, 215). There is a possibility of connection of this pool with the reservoir, but no data or finds can really state that.

A cistern dated to Iron II/Persian period was discovered at the south side of the tall. The cistern is bell shaped, having as described "an unusually long neck" of about 4 meters. Its base "forms a triangle 2.65 meters wide at the bottom and 2 meters to the beginning of the neck" (Merling 1994, 216). The cistern was not fully excavated, but its exposed area suggests that it could have hold around 15,000 liters of water. Tall Hesban like Tall Jalul is not adjacent to springs, and Ain Hisban is several kilometers away, therefore, depending only by runoff surface water from the rains within the settlement, either by the system of channels that fed the reservoir or as suggested the filling into the reservoir could have been completed by a large train of donkeys.

CHAPTER 4

COMPARISON BETWEEN SIMILAR STRUCTURES

In comparing the water systems, the location and the features of the settlement must be taken in consideration. The water system at Jerusalem is unique by the way it was constructed in both Warren's Shaft and Hezekiah's tunnel. In the former, the builders made use of natural karstic fissures in order to make their way from the entrance chamber until the vertical shaft of 14 meters high to catch the water by containers. Hezekiah's tunnel a length of 643 meters was a unique project, connecting a spring to an open pool. Although the horizontal tunnel of Megiddo was built for a similar purpose, its length, shape, form and capacity are significantly different from Hezekiah's tunnel.

Three water systems share similar features of engineering work, although during the process of construction differences are clear since each site was unique in its geography. Nevertheless, Megiddo, Hazor and Gibeon share the same goal that was to bring water safely within the city walls in times of siege. That generally occurred by the construction of shafts, sloping and horizontal tunnels that would reach the spring from which they could draw water either by lowering the floor of the horizontal tunnel or building small water channels such as at Gibeon that would allow water to be stored in a chamber or cistern room. At Hazor, although the goal of the project was to reach a spring groundwater from strands of the Dead Sea fault was found during the process of construction and a water chamber was set up there, as mentioned previously.

Those water systems as Barkay points out, conveyed water to the inhabitants (Barkay 1994, 333), and consequently were more developed than the water systems that bring the inhabitants to water. The round cistern and water channel at Qumran, and the reservoir at Hesban, differ from the cistern and channels at Megiddo, Hazor, Gibeon, and the water systems of Jerusalem on the method of capture and store water. Qumran and Hesban do not have adjacent springs and both the cistern and reservoir were filled by means of run-off surface water from within the settlement with the help of the water channels, although water channels were not present in Hesban in Iron Age I.

CONCLUSION

The water system of Jalul has not been totally excavated, which makes it difficult to make comparisons with other water systems that have been fully excavated. Nevertheless, excavations in the open air reservoir have been made progress and revealed good data. The water channel has not been fully excavated either, therefore comparisons with other structures are restricted until it is totally excavated. In addition, no spring or underground water sources were found yet in Jalul.

The water system of Jalul differs from the Warren's Shaft in many aspects. Whereas the Warren's shaft was hewn in natural karstic fissures, and had a series of phases in order to reach the water, Jalul's reservoir on other hand is on top of the bedrock and works as open air structure, having until now, no traces of springs or underground water to which it was supplied. Hezekiah's tunnel also diverges in many aspects from the water system at Jalul, but mainly in terms of function and the material with each were built. Hezekiah's tunnel, a length of 643 meters connects a spring to a pool, while the precise function of the water channel of Jalul is still unknown. Taking into consideration some of the conclusions of the excavators, that the channel functioned to empty water from the reservoir, possibly leading to pools outside of the city, the function of both tunnel and channel were completely different for their inhabitants. Hezekiah's tunnel would lead water inside of the city walls, and the water channel of Jalul it would seem to lead water outside of the city walls. Although this water was not wasted it could be a problem in times of siege, since the enemy would have access to water outside of the city.

The water systems at Gibeon, Hazor and Megiddo are far more developed than the water system of Jalul, making use of springs and groundwater to be stored in cistern rooms. The reservoir at Jalul on other hand, was constantly exposed to the heating in the air, therefore storing water of lower quality that could quickly evaporate.

The water systems of Qumran and Hesban share common features with the water system at Jalul. The round cistern at Qumran could have contained 125,000 liters, while the reservoir of Jalul could have contained 1800000 liters. The reservoir of Jalul is bigger in size than the Hesban's reservoir and both were plastered inside. Major differences between the three water systems have to do with the function of the water channel. While at Qumran the round cistern, and Hesban's reservoir in its Iron II phases were supplied by the water channel during the rainy season, the water channel of Jalul apparently was built to do the opposite function, that was to get rid of the excess of water from the site. Major points in common are that all three water systems were designed to capture and store surface water, involving stone masonry in their construction, and all three were connected in some aspect with plastered channels.

Excavations on the water system of Tall Jalul are still in progress, and there is still much to be revealed in regard to the reservoir and the water channel. Future excavations will, perhaps, reveal the real function of the water channel, bringing a definitely answer to its mysteries. The search for stairs and for a natural source that supplied the reservoir is the main goal of the excavators and hopefully future excavations will bring new data and perhaps a definitive answer regarding its function. Tall Jalul's 10^{th} century B.C. reservoir remains the biggest by volume open air reservoir in the all Ancient Near East. The present work is not the end of the study of the water systems of Tall Jalu, and future excavations may elaborate more on the analysis of the site and its identification.

REFERENCE LIST

Barkay, Gabriel. “The Iron Age II-III.” In *The Archaeology of Ancient Israel,* edited by A. Ben-Tor, 302-73. New Haven, CT: Yale University, 1992.

Bienkowski, Piotr and Allan Millard, eds. *Dictionary of the Ancient Near East*. Philadelphia, PA: University of Pennsylvania Press, 2000.

Cole, Dan P. “How Water Tunnels Worked.” *Biblical Archaeology Review*, 6, 1980, pp. 8-29.

Cross, Frank M., and Józef T. Milik. “Explorations in the Judaean Buqê'ah.” *Bulletin of the American Schools of Oriental Research*, 142, 1956, pp. 5-17.

Frumkin, Amos and Aryeh Shimron. “Tunnel Engineering in the Iron Age: Geoarchaeology of the Siloam Tunnel, Jerusalem.” *Journal of Archaeological Science,* 33, 2006, pp. 227-37.

Gane, Constance, Randal W. Younker, Paul J. Ray, Karen Borstad, Teddy Burgh, Roy Gane, Paul Z. Gregor, Jennifer Groves, and Reem Al Shqour. “Madaba Plains Project: Tall Jalul 2009.” *Andrews University Seminary Studies*, 48, 2010, pp. 165-223.

Gregor, Paul Z. *Water Systems in the Levant: Newest Discoveries from Tall Jalul*. Faculty Publications. Paper 108, 2014.

Gregor, Paul Z., and Helena Gregor. “Preliminary Report on the 2009 and 2010 Seasons: Field G and W.” *Annual of the Department of Antiquities of Jordan*, 54, 2010, pp. 493-98.

Gregor, Paul Z., Constance. E. Gane, Helena Gregor, Randal W. Younker and Paul J. Ray. “Preliminary Report on the 2014 and 2015 Seasons of the Madaba Plains Project: Tall Jalul Excavations 2014 and 2015.” *Annual of the Department of Antiquities of Jordan*, forthcoming.

Gregor, Paul Z., Paul J. Ray., Randal W. Younker, and Costance Gane. “Preliminary Report on the 2011 Season of the Madaba Plains Project: Tall Jalul Excavation 2011.” *Annual of the Department of Antiquities of Jordan*, 55, 2011, pp. 351-62.

Gregor, Paul Z., Randal W. Younker., and Paul J. Ray. "Preliminary Report on the 2012 Season of the Madaba Plains Project: Tall Jalul Excavations 2012." *Annual of the Department of Antiquities of Jordan*, 56, 2012, pp. 201-205.

Herr, Larry G. "The Iron Age II Period: Emerging Nations." *Biblical Archaeologist*, 60, 1997, pp. 114-83.

______. "The Ammonites in the Late Iron Age and Persian Period." in *Ancient Ammon*, edited by Burton MacDonald and Randal W. Younker, 219-37. Leiden, NL: Brill, 1999.

Hidiroglou, Patricia, and Claude Grenache. "Aqueducts, Basins, and Cisterns: The Water Systems at Qumran." *Near Eastern Archaeology*, 63, 2000, pp. 138-39.

Hopkins, David C., "The Subsistence Struggles of Early Israel." *Biblical Archaeologist*, 50, 1987, pp. 178-91.

Horn, Siegfried H., *Heshbon in the Bible and Archaeology*. Berrien Springs, MI: The Siegfried H. Horn Archaeological Museum, 1982.

King, Philip J., and Lawrence Stager. *Life in Biblical Israel.* Louisville, KY: Westminster John Knox, 2001.

Lamon, Robert S., *The Megiddo Water System.* Chicago, IL: The University of Chicago Press, 1935.

Mazar, Amihai. *Archaeology of the Land of the Bible, 10,000-586 B.C.E.* New York, NY: Doubleday, 1992.

Merling, D. "The Pools of Heshbon: As Discovered by the Heshbon Expedition." In *Hesban After 25 Years*, edited by David Merling and Lawrence T. Geralty, 211-23. Berrien Springs, MI: Institute of Archaeology/Siegfried Horn Museum, Andrews University, 1994.

Negev, Avraham, and Shimon Gibson. *Archaeological Encyclopedia of the Holy Land*. New York, NY: The Continuum Publishing Group Inc, 2001.

Oleson, John P., "Water Works" in Vol. 6 of *The Anchor Bible Dictionary*, edited by. David N. Freedman, 883-93. New York, NY: Doubleday, 1992.

Prestes, Carina de O. "The Architecture of Tell Jalul." MA Thesis, Andrews University, 2014.

Pritchard, James B., *Ancient Near Eastern Texts Relating to the Old Testament*, 3rd ed. Princeton, NJ: Princeton University Press, 1969.

______. “The Water System at Gibeon.” *The Biblical Archaeologist*, 19, 1956, pp. 65-75.

______. *The Water System of Gibeon.* Philadelphia, PA: The University Museum, 1961.

Ray, Paul. *Tell Hesban and Vicinity in the Iron Age*. Berrien Springs, MI: Andrews University Press, 2001.

Reich, Ronny and Eli Shukron, “Light at the End of the Tunnel*” Biblical Archaeology Review* 25, 1999, pp. 22-34.

Sauer, James A. “Heshbon 1973: Area B and Square D.4.” *Andrews University Seminary Studies*, 13.2, 1975, pp. 133-67.

______. “Heshbon 1974: Area B and Square D.4.” *Andrews University Seminary Studies*, 14.1, 1976, pp. 29-62.

______. “The Pottery at Hesban and Its Relationships to the History of Jordan: An Interim Hesban Pottery Report, 1993.” In *Hesban After 25 years*, edited by David Merling and Lawrence T. Geralty, 225-81. Berrien Springs, MI: Institute of Archaeology/Horn Archaeological Museum, 1994.

Shiloh, Yosef. “Underground Water Systems in the Land of Israel in the Iron Age.” *The Architecture of Ancient Israel: From the Prehistoric to the Persian Periods*, edited by Aharon Kempinski and Ronny Reich, 275-93. Jerusalem: Israel Exploration Society, 1992.

Yadin, Yigael. “The Fifth Season of Excavations at Hazor, 1968-1969.” *The Biblical Archaeologist*, 32, 1969, pp. 50-71.

______. “Megiddo of the Kings of Israel.” *The Biblical Archaeologist*, 33, 1970, pp. 65-96.

______. *Masada; Herod’s Fortress and the Zealots’ Last Stand*. Tel Aviv, Israel: Steimatzky LTD, 1984.

Younker, Gane, and Reem Shqour. “Tall Jalul Excavations/Madaba Plains Project” *Munjazat*, 8, 2007, pp. 82-83.

Weinberger, Sneh, and Eyal Shalev. “Hydrological Insights in Antiquity as Indicated by Canaanite and Israelite Water Systems.” *Journal of Archaeological Science*, 35, 2008, pp. 3035-42.

Wood, Bryant. G. “To Dip or Sprinkle? The Qumran Cisterns in Perspective.” *Bulletin of the American Schools of Oriental Research*, 256, 1994, pp. 45-60.