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Filer:	Nikola Lakic
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Harnessing Energy and Water in The Salton Sea (Segm. II) (Harnessing Hydro Power)

Nikola N. Lakic

Geothermal Worldwide, Inc.

78-365 Hwy 111, #402, La Quinta, CA 92253

E-mail address: nlakic@GeothermalWorldwide.com

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ABSTRACT

The Salton Sea in California is a terminal lake with reduced inflow from the Colorado River as a result of the water transfers related to the Quantification Settlement Agreement (QSA). The Lake is shrinking and exposing the receding shoreline (toxic playa) to the elements and facing incoming environmental disaster.

The presented proposal includes an architectural element that harmoniously incorporates several patented technologies into a self-sustaining organism. It is a long-term solution for the restoration of the Salton Sea.

The presented proposal includes several options based on the same concept: 1) Dividing the Lake into three sections; 2) Importing seawater from the Ocean; 3) Harnessing prevalent geothermal energy.

In this segment (II), the emphasis is on Harnessing Hydro Power during the import of seawater from the Ocean. The presented system for importing seawater is the essential phase for harnessing geothermal energy and for the restoration of the Salton Sea, CA, although is not limited to the Salton Sea project.

Contemporary pumping stations and hydroelectric power plants are expensive and have restrictions on location, capacity, and access. The presented proposal for importing seawater has several "In-line-Pumps" as segments of the pipeline for uphill routes and has several "In-Line-Generator" as segments of the pipeline for generating electricity on downhill routes. This system also has "Split and Join" and "Delta" mini Hydroelectric Power Plants on downhill routes.

1. Introduction

The presented system for importing seawater is the essential phase for harnessing geothermal energy and for the restoration of the Salton Sea, CA, although is not limited to the Salton Sea project.

Contemporary pumping stations and hydroelectric power plants are expensive and have restrictions on location, capacity, and access. The presented proposal for importing seawater has several "In-line-Pumps" as segments of the pipeline for the uphill routes and has several "in-line-generator" as segments of the pipeline for generating electricity on downhill routes (See Fig. 1-4). This system also has "Split and Join" and "Delta" mini Hydroelectric Power Plants on downhill routes. Downhill routes of the pipeline can be built using several cascades with "split and join" mini Hydroelectric Power Plants to avoid the buildup of extreme hydrostatic pressure in the pipeline especially in the last section of the final downhill routes (See Fig. 4 and 5). The system uses primary and secondary "In-Line-Generators" (See Fig. 6-8). The primary "In-Line-Generators" are the first generators after the cascade drop with less exposed spiral blades inside the shaft/pipe generating electricity and allowing fluid flow to continue to the subsequent smaller diameter pipes with slightly lesser speed. After exiting the primary "In-line-generators", the fluid flow is split into two subsequent smaller branches with smaller "In-line-generators" which have more exposed spiral blades inside shaft/pipe and lesser opening in the middle. By splitting fluid flow into smaller branches with a lesser speed of fluid flow in each subsequent branch, it increases the efficiency of harnessing kinetic energy and at the same time providing the same mass of water to leave the pipeline and enter the lake as the amount of water exiting the primary "In-Line-Generators". In order to accommodate the same amount of water exiting the downhill pipeline and Delta" mini Hydroelectric Power Plant, the same amount of water needs to enter the pipeline at the uphill route from the Ocean. That is achieved by having several pipelines comprising the uphill route with lesser fluid speed through them.

1.1 Preliminary Estimate for the Cost and Energy Needed for the Pipeline Route # 1: From Gulf of California – San Felipe - Mexicali, Mexico, - To the Salton Sea.

Elevation to overcome is 35' (10 m).

Pipeline distance is about 150 miles.

The range of cost today of installed pressure pipe of 48-inch diameter in various terrains is about $600 – $1,000 per linear foot.

Route # 1 has a distance of about 150 miles with preferred topography which has an advantage in pipeline cost. Let's assume $600 per linear foot.

One mile 5,280' x $600 = $3,168,000.

$3,168,000 x 450 miles relatively flat terrain (50 miles x 5 pipelines + 50 miles x 3 pipelines 50 miles 1 pipeline) = $1,425,600,000

Because of a new product development + several pumping stations which will work temporally + final "delta" mini Hydroelectric Power Plant on the final route + adding several freeway underpasses, right-of-way permits - the final cost might increase 20% to about $1.7 billion.

As an option, if to pump-out higher salinity water from the bottom of the Lake into the vast Ocean is accepted through negotiation with Mexico authorities, then the same pumping system for importing seawater, with minor modifications, can be used for exporting higher salinity water (which has tendencies to accumulates at the bottom of the lake) from the Salton Sea into the Ocean by switching the direction of rotation of the In-Line-Pump/Generator 572 and 573 (See FIGS. 6-8). Reverse flow can be activated periodically for example - two weeks twice a year.

1.2 Preliminary Estimate of Energy Needed for the Pipeline Route # 1: Importing Seawater from the Gulf of California – Corridor: San Felipe - Mexicali, Mexico, to the Salton Sea.

Pipeline distance is about 150 miles.

Free Fall 70 meters:

Diameter of pipe is 48"

$S = ½ g x t^2$;

S = Vertical distance;

g = gravity = 9.81;

t = time

A = Area of the cross-section of the pipe.

$A = \pi r^2$ = 3.14 x (2x2) = 12.56 f^2

12.56 f^2 / 9 = 1.39 y^2 = 1.16 m^2

Free Fall values at 70 meters drop:

$S = ½ g x t^2$

$70 = ½ x 9.81 x t^2$

$t^2 = 140 / 9.81 = 14.27$

$t = \sqrt{14.27} = 3.77$ seconds

Speed of water at nozzle at the bottom of the vertical fall at 70 meters:

V = Velocity (Speed)

V = g x t

V = 9.81 x 3.77 = 37.05 meters per second (41.01 y/s)

The volume of seawater entering the lake through one pipe with diameter 48" at speed of 41.0 y/s (yard per second) is: 1.39 y^2 x 41.0 y per sec. = 57.00 y^3 x (31,536,000 seconds in a year) = 1,797,674,900 y^3 = **1,114,261 acre-foot per year.**

The volume (mass) of water needed to balance the evaporation of the central section of the Lake is about 1,000,000-acre foot per year.

V = velocity => 7.4 m/s = 8.2 y/s is the speed that is needed to pump water from the Ocean through each of 5 pipelines of 48" diameter to accommodate the volume of seawater entering the Lake through one pipe with diameter 48" at speed of 41.0 y/s (yard per second).

The volume (mass) of water (42,720 kg) per second exiting the primary in-line-generator at speed of 37 m/s (41 y/s) and after "delta" mini hydroelectric power plant entering the Salton Sea is the same volume (mass) of water (42,720 kg) per second entering 5 pipelines in Gulf of Mexico at speed of 7.4 m/s (8.2 y/s).

Kinetic Energy:

For 70-meter drop from the top of the hill to the surface of the lake

The surface of the Lake is 70 meters below the ocean level.

Velocity (Speed) of the water at the surface of Lake or at nuzzle (in-line generator) is 37.05 m/s (41.01 y/s)

$E_k = \frac{1}{2} M \times V^2$

Ek = Kinetic Energy

M = Mass

V = Velocity

M = Ek x 2/ V^2 => M = 1.16 m^2 x 37.05 m/s = 42.98 => 42.98 x (994kg = weight of water at 100 ° F) = 42,720kg

(42,720 kg is the volume (mass) of water passing through pipeline per second).

Ek = ½ M x V^2 = ½ x 42,720 kg x (37.05 x 37.05) => ½ x 42,720 kg x 1,372.7

=> ½ 58,641,744 = 29,320,872 MWs in period of one hour it is 29.3 MWh.

Efficiency factor usually used is 15% loss => 29.3 MWh x 0.85 = 24.9 MWh.

At this early stage without final testing of the new system, it is realistic to expect that by using "delta" mini hydroelectric power plants which harness energy after the main turbine (Primary In-Line-Generator) using mass and speed of fluid (no gravity) can be harnessed an additional 10% of energy which is about 2.4 MWh which end up to about **27.3 MWh**.

Revenue**:** **27.3 MWh** x \$60 = \$1,638 per hour;

\$1,638 x 24 hours = \$39,3210 per day;

\$91,310 x 365 days = **\$14,348,880** per year;

It is realistic to expect that starting with 5 pipelines with a diameter of 48" and speed of seawater 7.4 m/s (8.2 y/s) at the Gulf of California (near San Felipe) and then gradually reducing the number of pipelines to 3 pipelines and 1pipeline through several sections of 50 miles (50 miles x 5 pipelines + 50 miles x 3 pipelines + 50 miles 1 pipeline See GIG. 1) in a few weeks the speed of seawater through the pipeline will be stabilized and will continue without using initial in-line-pumps at the entrance of the pipeline.

1.3 Preliminary Estimate for Cost and Energy Needed for the Pipeline Route # 2: Importing Seawater from Long Beach California to the Salton Sea.

Elevation to overcome is 2,700' (823 m).

Pipeline distance is about 200 miles.

There is "Inland California Express" - Existing Pipeline – 60-year-old - diameter 16" for crude oil - 96 miles long from Long Beach to Whitewater area. The Questar Company owns the pipeline. The pipeline is not operational now. The Questar Company has "Right of Way" and is willing to sell it. Emphasis is on the "Right of Way".

The presented new pipeline is 48" in diameter. Downhill routes of the pipeline can be built using several cascades with "split and join" hydropower plants to avoid the buildup of extreme pressure in the pipeline especially in the last section of the final downhill route. By using several cascades with several "split and join" and "delta" hydropower stations this system can harness more kinetic energy.

1.4 Preliminary Estimate of Energy Needed for the Pipeline Route # 2: Importing Seawater from Long Beach California to the Salton Sea.

Free Fall values at 823 meters + (70 meters Ocean to Lake difference) = 893 meters

On this route can be used 3 cascades each with 297 m drop and 9 uphill pumping stations.

Free Fall:

$S = \frac{1}{2} g \times t^2$;

S = Vertical distance;

g = gravity = 9.81;

t = time

Free Fall values at 297 meters

$S = \frac{1}{2} g \times t^2$

$297 = \frac{1}{2} \times 9.81 \times t^2$

$t^2 = 594 / 9.81 = 60.55$

$t = \sqrt{60.55} = 7.78$ seconds

Speed of water at nozzle at the bottom of the vertical fall at 297 meters:

V = Viscosity (Speed)

$V = g \times t$

V = 9.81 x 7.78 = 76.33 m/s = (83.47 y/s).

The volume of seawater entering the lake through one pipe with diameter 48" at speed of 83.47 y/s (yard per second) is: 1.39 y^2 x 83.47 y per sec. = 116 y^3 x (31,536,000 seconds in a year) = 3,658,176,000 y^3 = **2,267,464 acre-foot per year**.

The volume (mass) of water needed to balance the evaporation of the central section of the Lake is about a 1,000,000 acre-foot per year.

V = velocity => 15.26 m/s = 16.7 y/s is the speed that is needed to pump water from the Ocean through each of 5 pipelines of 48" diameter to accommodate the volume of seawater entering the Lake through one pipe with diameter 48" at speed of 76.33 m/s = (83.47 yards per second).

The volume (mass) of water (88,008 kg [42,720 kg]) per second exiting the primary in-line-generator at speed of 76.33 m/s = (83.47 y/s) and after the "delta" mini hydroelectric power plant entering the Salton Sea is the same volume (mass) of water 88,008 kg per second entering 5 pipelines in Long Beach at speed of 15.26 m/s = (16.7 y/s).

Kinetic Energy

For 297 m drop (first cascade) to the first in-line-turbine /generator.

Speed of the water at the exit of first in-line-generator is 76.33 m/s = (83.47 y/s)

$Ek = \frac{1}{2} M \times V^2$

Ek = Kinetic Energy

M = Mass

$M = Ek \times 2 / V^2$

M = 1.16 m^2 x 76.33 m/s = 88.54 m^3 => 88.54 x (994kg = weight of water at 100 ° F) = 88,008kg (88,008 kg is the volume (mass) of water per second).

Ek = ½ M x V^2 = ½ x 88,008 kg x (76.33 m/s x 76.33 m/s) => ½ x 88,008 kg x 5,826 m/s => ½ 512,734,600 = 256,367,300 MWs => in period of one hour it is 256.36 MWh

Efficiency factor usually used is 15% loss => 256.36 MWh x 0.85 = 217.90 MWh

Three such cascade drops add to 217.90 MWh x 3 (cascade drops) = 653.7 MWh

At this early stage without final testing of the new system, it is realistic to expect that by using "split and join" and "delta" hydropower plant which harness energy after fluid leaves the primary In-Line-Generator (main turbine) using mass and speed of fluid (no gravity) can be harnessed at least additional 10% of energy which is about 65.3 MWh. In this case, it ends up to about 719.0 MWh.

The energy needed to transport the same amount of water through uphill pipeline section(s) which in this case (Route # 2 elevation 2,700' (823 m):

EP = M x g x h = 88,008 kg x 9.81 x 823 m = 710,544,020 MWs in an hour it is 710.5 MWh

Efficiency factor is used 40% => 710.5 MWh x 1.4 = 994.7 MWh.

Energy Net for Route # 2: 719.0 MWh – 994.7 MWh = - 275.7 MWh

(The section "2" below is added later after submission of paper)

2. Preliminary Cost Estimate and Revenue for the pipeline system for irrigation for farmland Southern area of the Salton Sea:

The presented proposal shows south area from the Lake (from the Lake to the border with Mexico) having three main pipelines (central, western, and eastern) and numerous perpendicular ribs lines (See segment I, FIGS. 3, 4, 5).

The rough estimate of the length of all together pipelines is about 870 miles (40 miles West line + 50 miles Central line + 60 miles eastern line = 150 miles + (24 ribs lines x 30 miles = 720 miles) => 870 miles.

2.1 Preliminary Cost Estimate and Revenue for the pipeline system for irrigation for the farmland area Southern from the Salton Sea:

The summary of the length of the pipeline system for irrigation for the farmland area Southern from the Salton Sea is about 870 miles.

The range of cost today of installed pressure pipe of 48-inch diameter in various terrains is about $600 – $1,000 per linear foot.

Because of preferred topography, a relatively flat terrain in this area, which has an advantage in pipeline cost it is selected $600 per linear foot.

One mile 5,280‘ x $600 = $3,168,000 per mile.

$3,168,000 x 870 miles = **$2,756,160,000.**

2.1.1 Preliminary Cost Estimate for Energy Generated and Revenue from hydropower of the pipeline system used for irrigation for the farmland area Southern from the Salton Sea:

The topography of the terrain from border with Mexico to the Salton Sea is about 8% slope. The elevation of the Mexicali and Calexico (cities on the border) is about 10-15 feet above the Ocean. The Salton Sea is -220 feet below the Ocean.

The West line of the pipeline system for irrigation is parallel with the section of the pipeline for importing seawater Route #1. Therefore, for easier calculation we will use the values calculated earlier in the section (1.2) "The volume of seawater entering the lake through one pipe with diameter 48" at speed of 41.0 y/s (yard per second) is: 1.39 y^2 x 41.0 y per sec. = 57.00 y^3 x (31,536,000 seconds in a year) = 1,797,674,900 y^3 = 1,114,261 acre-foot per year". Energy generated is about 27.3 MWh.

The surface of the South Section of the Lake is about 10% of the surface of the whole Lake. Therefore, the volume (mass) of water needed to balance the evaporation of the South Section of the Lake is about 120,000 acre-foot per year.

The South Section of the Lake is supply with water from All-American Canal near the border with Mexico. The needed water for farmland is about 200,000 acre-feet per year. The water 120,000 acre-foot per year entering the South Section of the Lake can be harnessed with the "Delta Power Plant".

Revenue**:** **2.73 MWh** x $60 = $163.8 per hour.

$163.8 x 24 hours = $3,930 per day;

$3,930 per day x 365 days = **$1,434,888 per year**.

3. Illustrations of the Segment (II) - Importing Seawater from the Ocean for the Restoration of the Salton Sea and for Harnessing Geothermal Energy.

Segment (II)

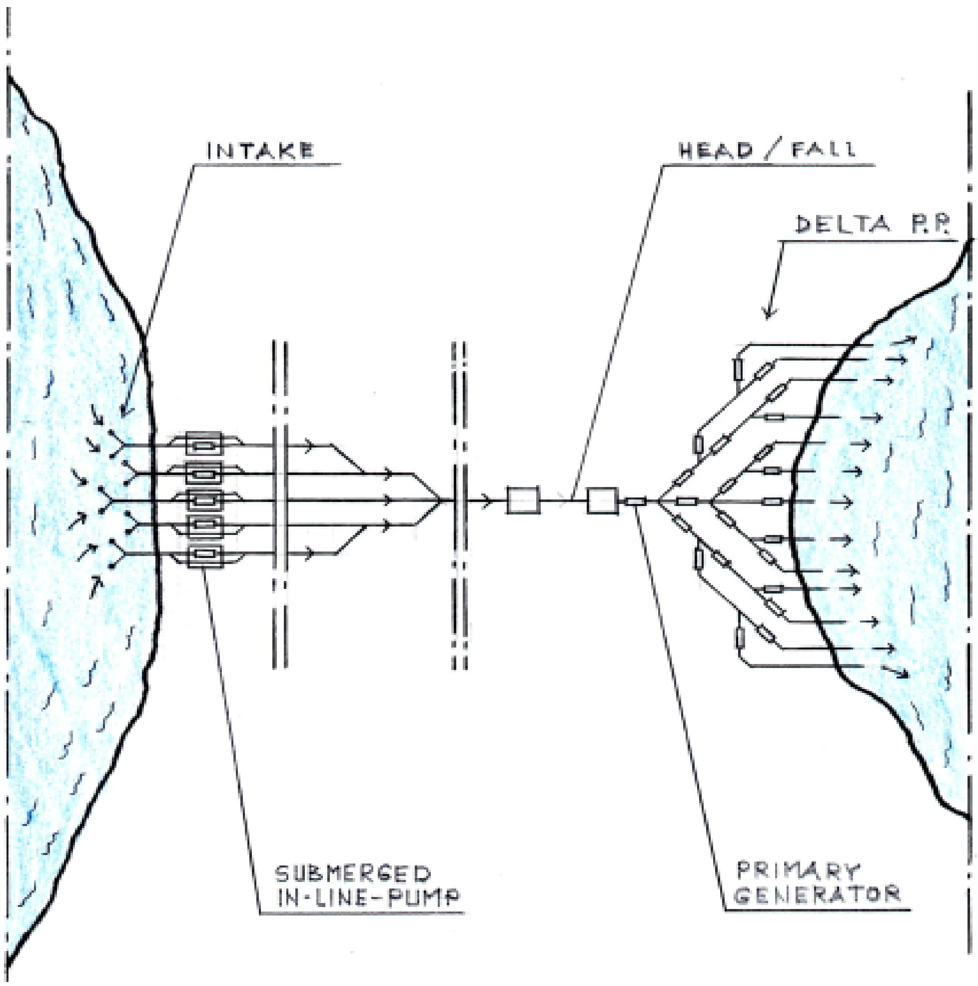


FIG. 1 – Plain View of several segments of the Route #1

Segment (II)

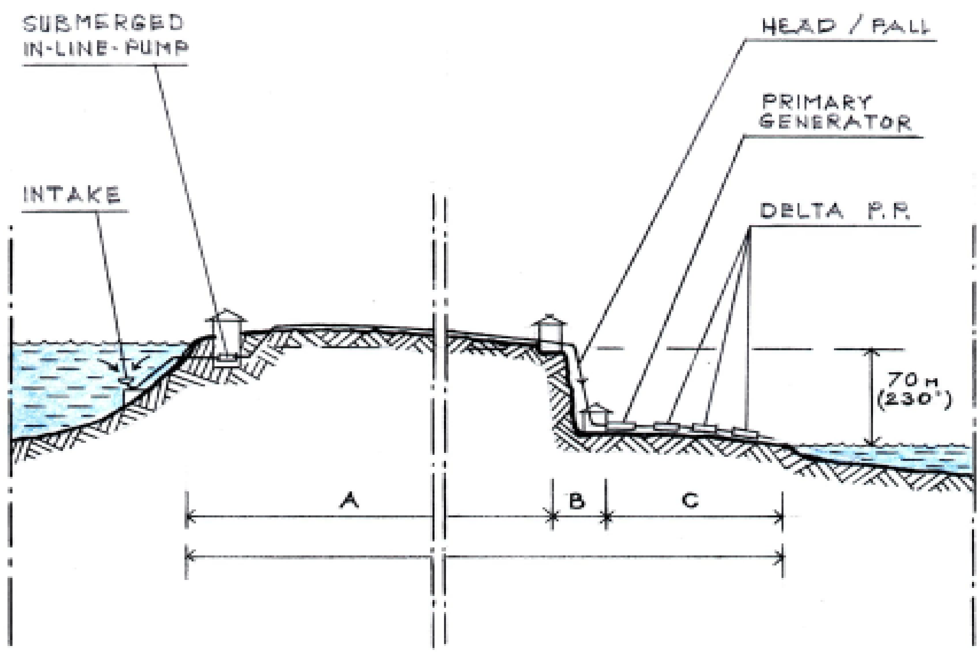


FIG. 2 – Cross-sectional View of the Route #1

Segment (II)

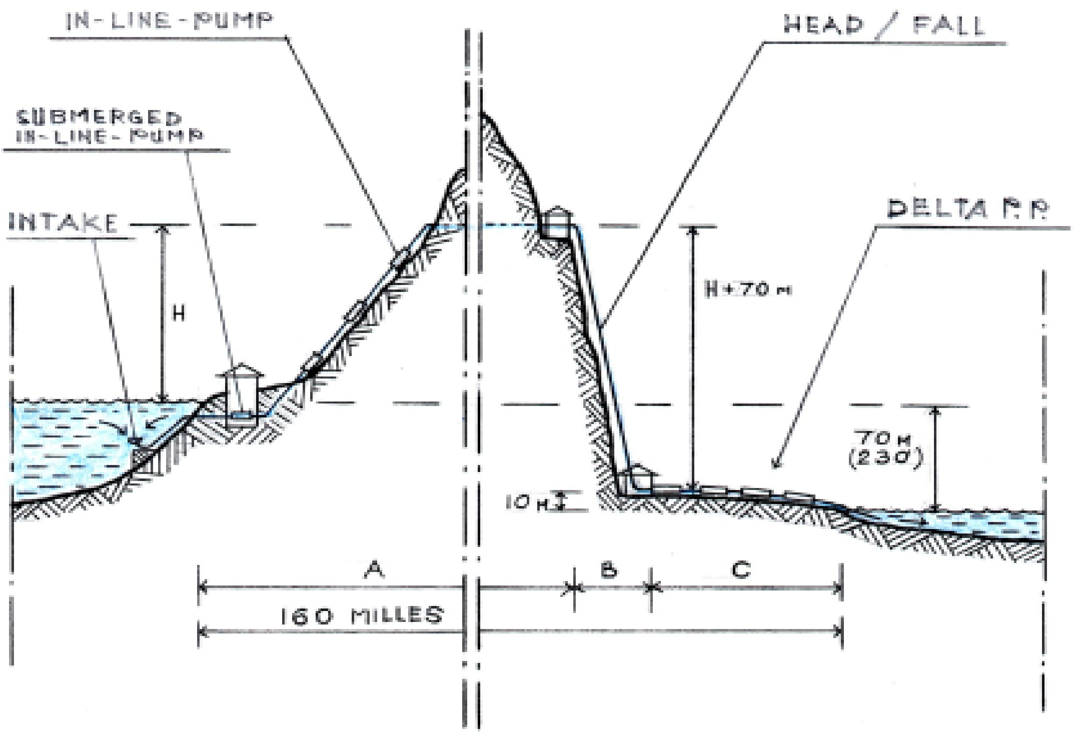


FIG. 3 – Cross-sectional View of Elevations of the Ocean and Salton Sea

Segment (II)

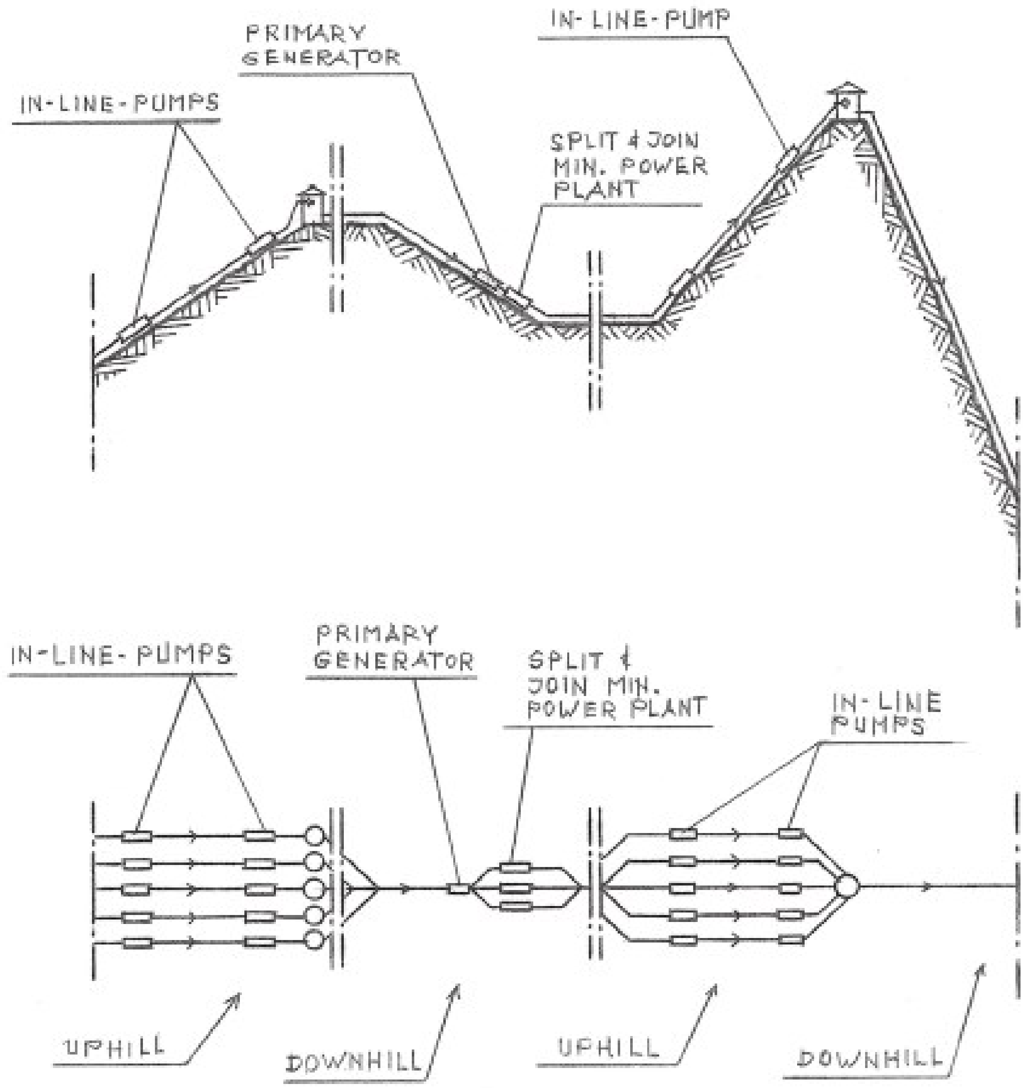
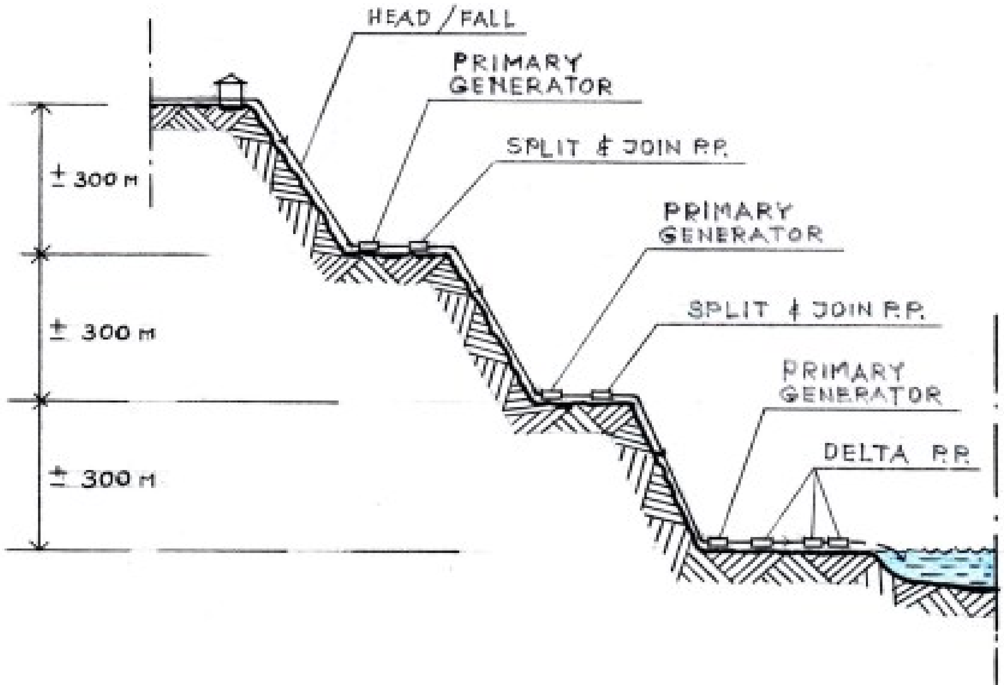


FIG. 4 – Plain and Cross-sectional View of the Mid-section of the Pipeline

Segment (II)



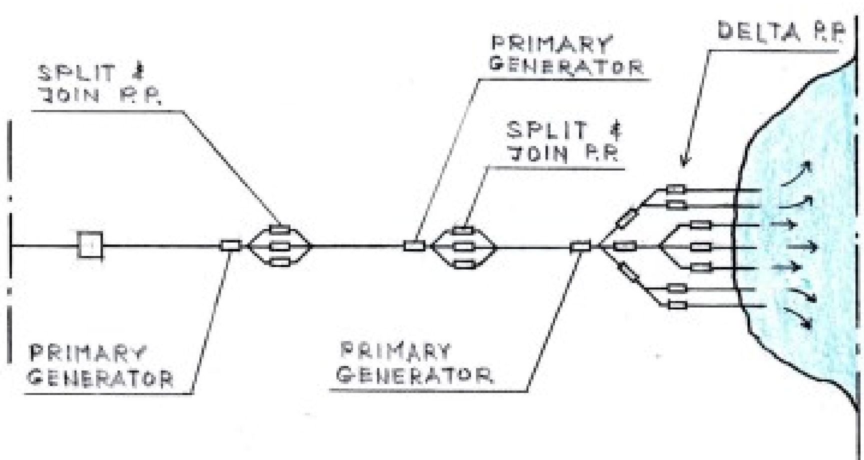


FIG. 5 – Plain and Cross-sectional View of the final downhill route

Segment (II)

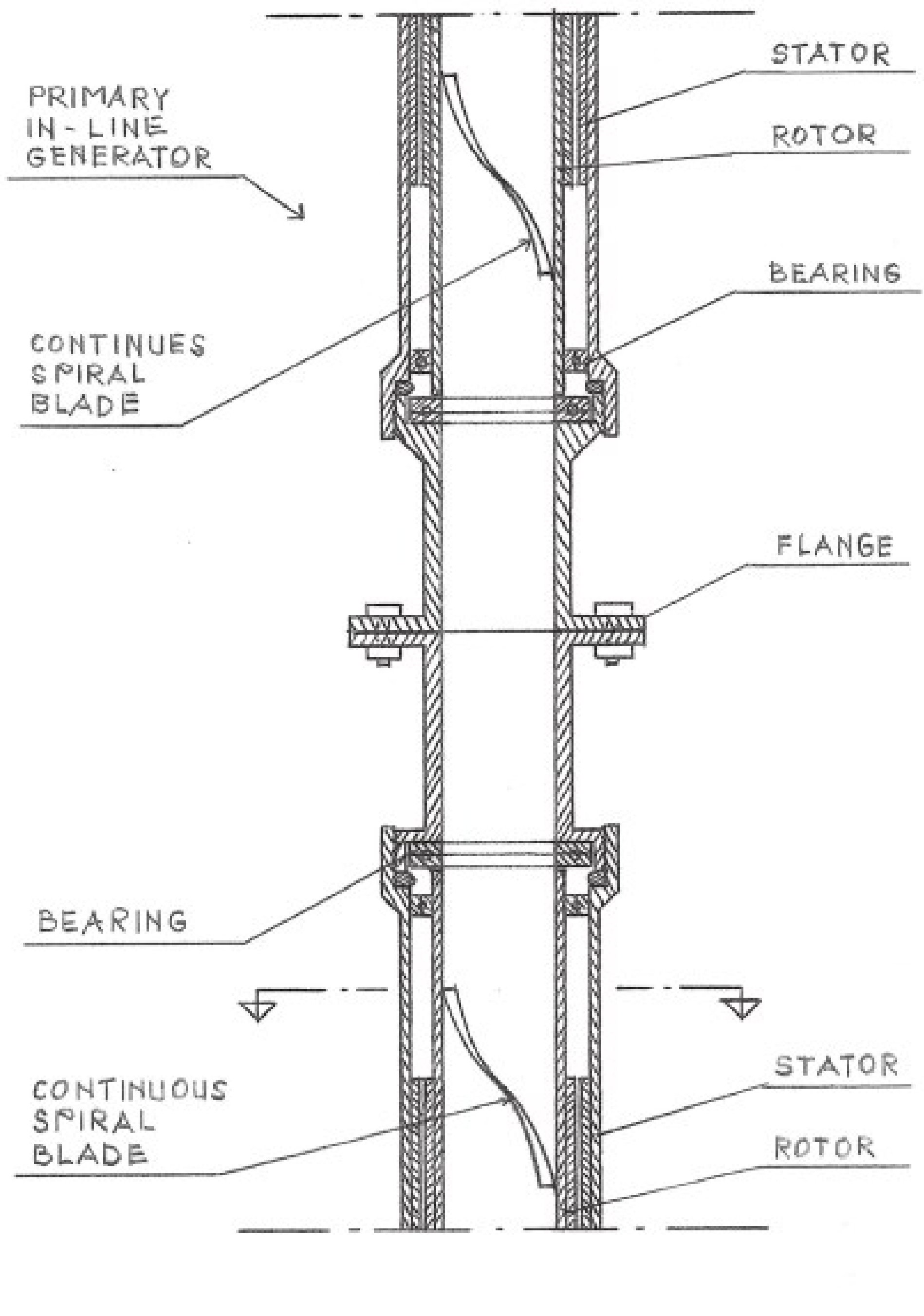


FIG. 6 – Cross-sectional longitudinal View of the Primary In-Line-Pump / Generator

Segment (II)

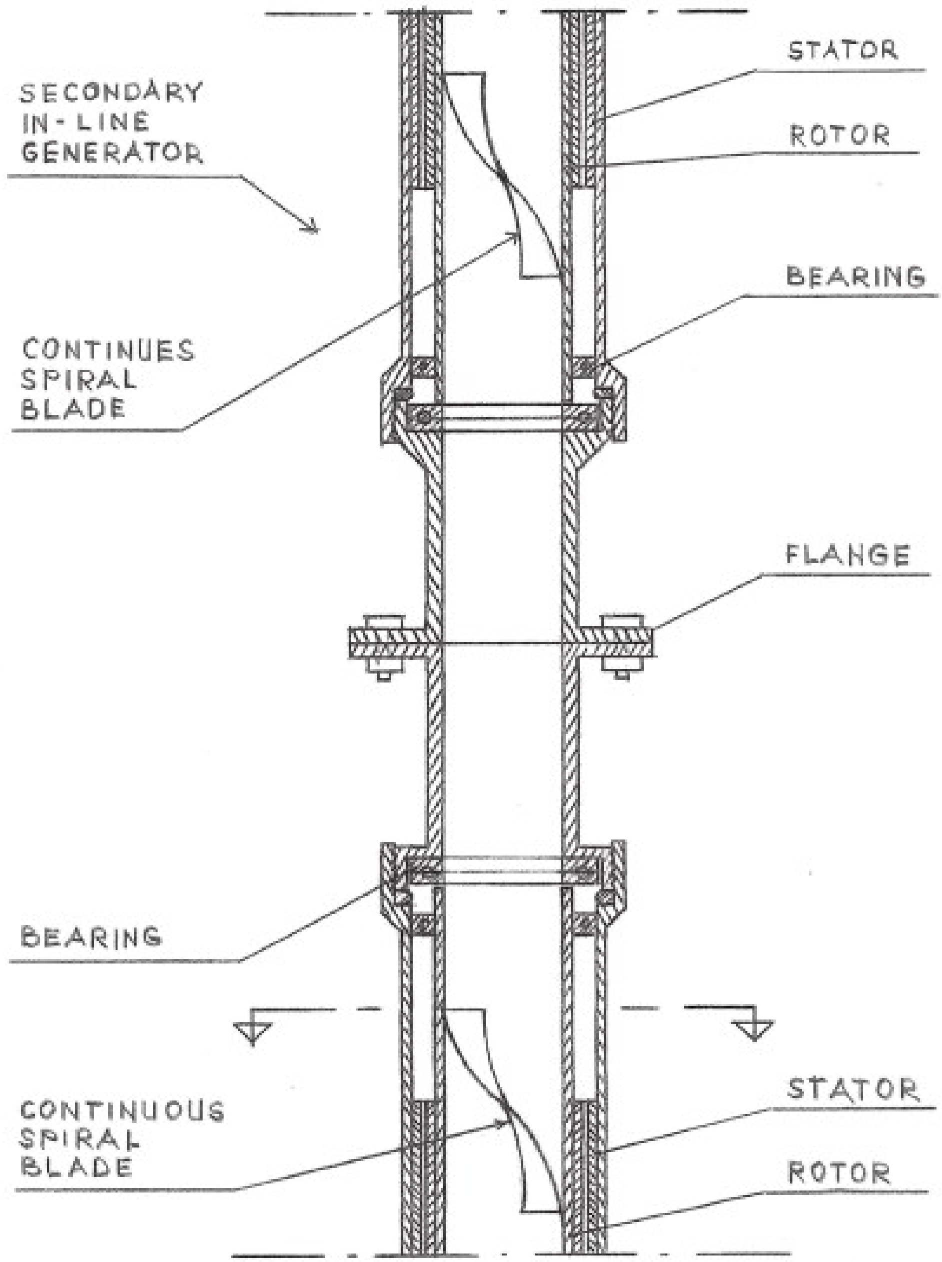


FIG. 7 – Cross-sectional longitudinal View of the Secondary In-Line-Pump / Generator

Segment (II)

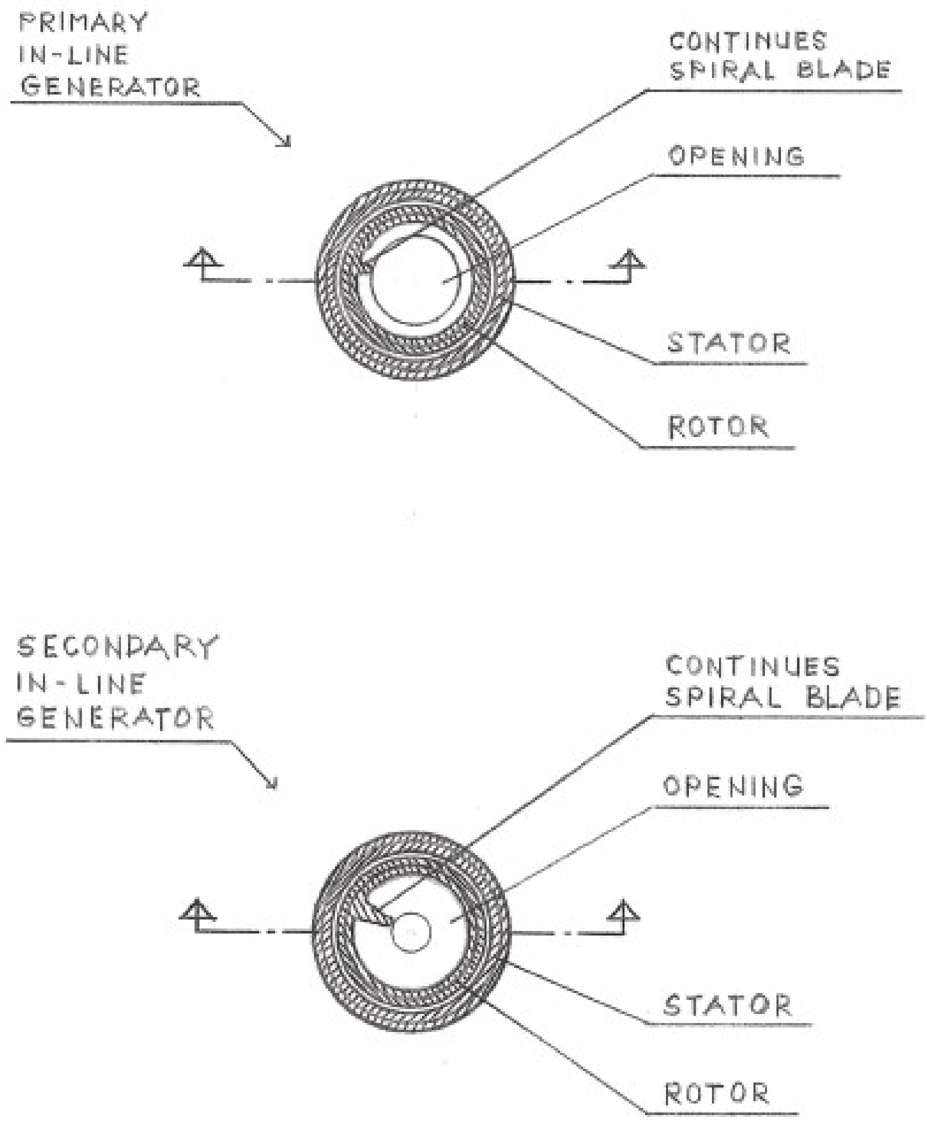


FIG. 8 – Cross-sectional Frontal View of the Primary and Secondary In-Line-Pump / Generator

3. Conclusion:

Importing seawater is a fundamental phase of the presented comprehensive proposal on which other phases depend. This segment also explains the function of necessary elements of the project and provides a rough cost estimate and potential revenue of the project proving the feasibility of the project.

Harnessing hydropower in downhill routes during the process of importing seawater is a fundamental value that makes the phase of importing seawater feasible on which other phases of this comprehensive project depend. Importing seawater is an essential element in providing the necessary water for harnessing geothermal energy in the area and is an essential element for the restoration of the Salton Sea.

Presented pipeline with a diameter of only 48" through Route #1 can import about 1 million acre-feet per year which is enough for the balancing evaporation of the Lake. The pipeline through Route #2 can import about 2 million acre-feet per year meaning that 1 million acre-feet can be used for other purposes including replenishing geothermal reservoirs.

Acknowledgment

The 3.5 km Temperature Map is courtesy of the SMU Geothermal Laboratory and Dr. David Blackwell, Dallas Texas.

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U.S. Patent No. 9,995,286; Entitled: "Self-Contained In-Ground Geothermal Generator and Heat Exchanger with In-Line Pump and Several Alternative Applications; Issued on June 12, 2018;