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# PROJECT DESCRIPTION


[Photo of Consultation Meeting of NIA Staff and Consultant Team]

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# 1 PROJECT DESCRIPTION

## 1.1 PROJECT LOCATION

The proposed Project encompasses the provinces of Ilocos Norte and Ilocos Sur, where the target service area is located; and the province of Abra, where the envisaged dams, reservoir and appurtenant structures are located.

The Project, through its irrigation canal network, will provide augmentative water supply to the existing irrigated areas, and basal water supply to the new service area—to achieve 2 crops of rice in a year, and, through its drainage canal network, to discard any excess water in the service area.

The target service area is 480 km from Metro Manila via the Manila–Ilocos Norte national highway, and 20 to 35 km south of the capital city of Laoag—bordered on the west by the West Philippine Sea and on the east by the Cordillera Central Mountains and Ilocos Mountain Range.

The service area covers whole or parts of 8 municipalities—such as Solsona, Dingras, Batac, Paoay, Pinili, Badoc, Nueva Era and Sinait—that are noted for the production of rice and nonrice field crops, like onion, garlic, tomato, and tobacco.

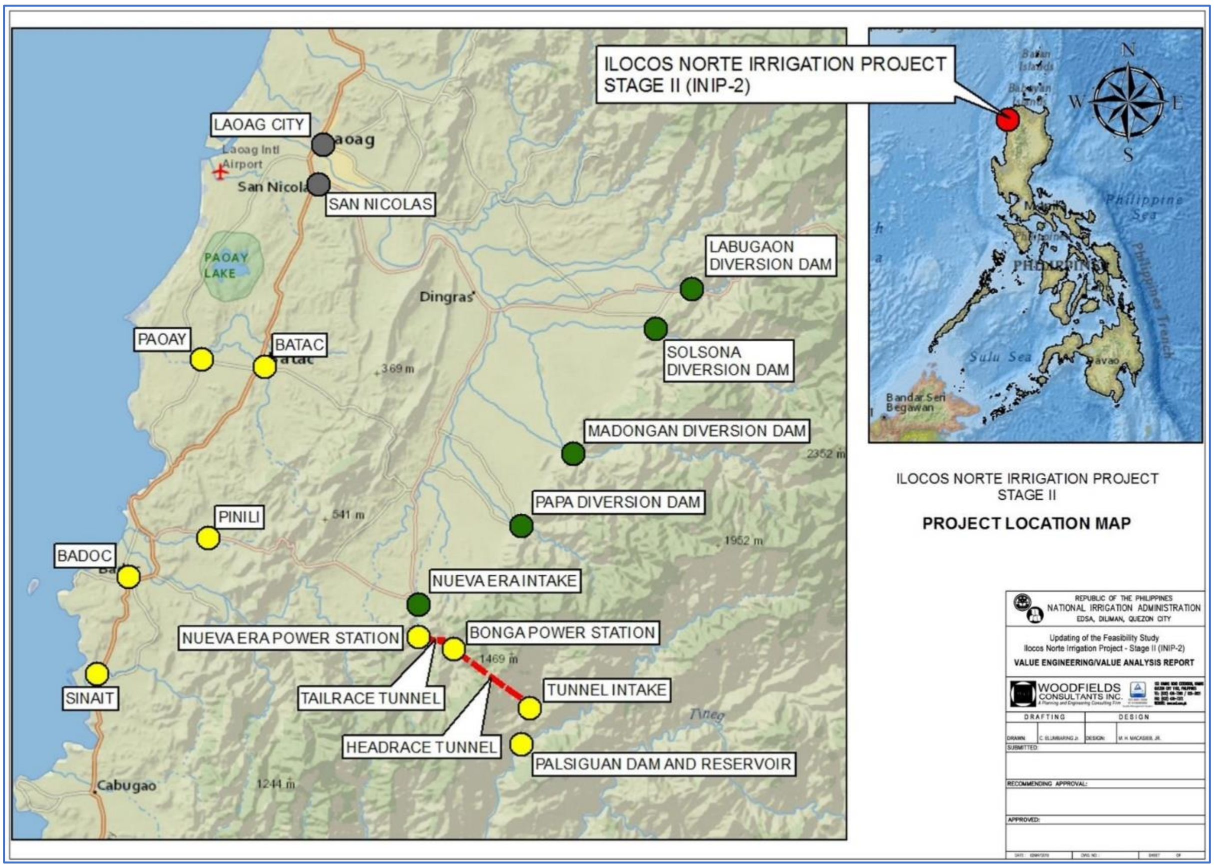



Figure 1: Project Location Map

## 1.2 PROJECT RATIONALE

Poverty incidence is most endemic in rural areas—so, the Project is, as envisioned, the physical intervention that would address the situation relying on its impact: increase cropping intensity and crop yield, would usher in more farm output, crop income and better farmers' lives.

A total of 16,447 ha is currently irrigated of the approximately 21,654 ha devoted to agriculture for the subproject, as of 2014. This covers the areas of Nueva Era, Dingras, Solsona, Badoc-Sinait, Pinili, and Batac-Paoay (Refer to **Error! Reference source not found.**). he data presented in **Error! Reference source not found.** and **Error! Reference source not found.** indicates a wide range of crop adaptability on a province – wide basis thus allowing farmers to exercise some degree of choice or decision in the adoption of their cropping pattern. Therefore, the same will be easily implementable in identified project areas considering the climatic and soil requirements and marketability of commodities or crops, production and yield data which have generally shown some encouraging results. Production protocols of indicated crops including their cost and return analysis are available through the municipal and city agriculturists and agricultural technologists for adoption and replication in farmers' production areas.

Table 1: Area Devoted to Agriculture, 2014

| Municipality | Irrigated (ha) | Rainfed (ha) | Upland (ha) | Total (ha) |
|---|---|---|---|---|
| Nueva Era | 608 | 364 | 3 | 975 |
| Dingras* | 6,217 | 410 | 98 | 6,725 |
| Solsona* | 3,622 | No data | No data | 3,622 |
| Badoc-Sinait | 1,136 | 1,250 | 57 | 2,443 |
| Pinili | 499 | 1070 | No data | 1,569 |
| Batac-Paoay | 4,365 | 1,890 | 65 | 6,320 |

** Dingras and Solsona are under Cura Area*
*** Badoc includes Madupayas Area*
*Source: Provincial Agriculture Office, Laoag City, Ilocos Norte*

Table 2: Updated Agricultural Profile, CY 2014

| Commodity | Area Harvested | Production (mt) | Yield (mt/ha) |
|---|---|---|---|
| Rice | 66,681.45 | 332,079.40 | 4.98 |
| Corn: | | | |
| Yellow | 8,511 | 47,358 | 5.60 |
| White | 3,151 | 11,295.5 | 3.60 |
| Fruit Vegetables: | | | |
| Ampalaya | 349.45 | 2,988 | 8.55 |
| Eggplant | 728 | 9,661 | 13.27 |
| Tomato | 1,459 | 31,326 | 21.47 |
| Okra | 138.50 | 1,342 | 9.69 |
| Upo | 172 | 2,194 | 12.76 |
| Patola | 178 | 1,707 | 9.58 |
| Leafy Vegetables: | | | |
| Pechay | 118 | 1,023 | 8.65 |
| Legumes: | | | |
| Mungbean | 4,193 | 5,810 | 1.39 |
| Peanut | 1,045 | 1,547 | 1.48 |

*Source: Provincial Agriculture Office, Laoag City, Province of Ilocos Norte*

Listed below are possible social and environmental benefits of the Project:

**A. Social Benefits:**

(1) Increased disposable income and savings;

(2) Active community participation in environmental programs and adoption of sustainable resource management practices;

(3) Enhanced quality of life due to improved water quality;

(4) Improved health status of the population as a result of healthier environment;

(5) Institutionalized stakeholders' participation in all aspects of project planning, implementation and evaluation;

(6) Mobilized communities demonstrating initiative and supporting all development programs;

(7) Established institutions and mechanisms for coordination and assistance among development partners to attain plan goals;

(8) Participation in governance of irrigation system; and

(9) Strengthened and empowered community – based organizations

**B. Environmental Benefits**

1. Enriched biodiversity. Through the watershed rehabilitation and protection program, habitats of flora and fauna shall be rehabilitated and preserved that shall, in turn, ensure long-term ecological balance and biodiversity;
2. Improved forest, soil and water conservation. With the application of appropriate conservation measures, forest, soil and water along with other natural resources shall be better protected and conserved, thus ensuring sustainability;
3. Shifting cultivation shall be minimized if not prevented with strict implementation of protection measures, thus reducing or preventing the risk or threat to forest areas. Better livelihood outlook is expected;
4. Enriched species/biodiversity;
5. Improved ecological biodiversity and hydrological productivity and sustainability as a result of rehabilitated watershed using vegetative measures and strategies; and
6. Increased community awareness for and concern in environmental protection and biodiversity conservation.

## 1.3 EXISTING GEOLOGICAL CONDITIONS

In summary, the existing geological condition within the two proposed dam sites will influence the level of safety of the component structures of the project. The geohazard assessment showed these findings;

1) The abutments of Palsiguan and Nueva Era Dams are cut by fault as shown by the drilling during the feasibility study stage of the project.

2) The Mines and Geosciences Bureau, PHIVOLCS and N Pinet (1990) have their own version of the geologic / structural map of the area. Based on the 3 maps, it is not clear where the Abra River Fault (a splay of the Philippine Fault) is located vis-à-vis with the location of the 2 dam sites and the tunnel corridor.

3) Aside from the Abra River Fault, other faults classified by PHIVOLCS as active are in close proximity to the Nueva Era Dam. These faults need to be reconciled with the faults of the MGB and Pinet.

4) A number of lineaments cuts the vicinity of the dam sites and tunnel corridor. The relationship of the faults that cut the abutments of the 2 dams, and the lineaments that cuts the tunnel corridor to the major fault lines identified by PHIVOLCS as active have to be defined

5) If the identified active fault in the area moves, what will be the possible direction of movement, extent of movement? Will the fault on the abutments of the dams also move and so with the other lineament? If yes, by how much and what kind of movement?

6) The International Commission on Large Dams (ICOLD) recommends that fault lines straddled by dams should be thoroughly studied. In the absence of such study, ICOLD recommends the dam should be relocated. In the case of the Palsiguan and Nueva Era dam sites, where will the relocation site be?

7) The headwater of the Bonga River, upstream of Nueva Era dam site is currently undergoing active degradation resulting to massive sediment deposition at the valley floor. Initial volume estimate of debris that can be generated by the degradation is from 2.5 to 8.3 M m3. The storage capacity and effective capacity of Nueva Era dam is 5.73 M m3 and 1.17 M m3 respectively indicating a very short life of the dam.

8) Aside from the fault intercepted by the drilling during the feasibility study and the sheer shown in the MGB Regional Geologic map of Banna Quadrangle (Sheet No. 3173-IV), the slope face of the reservoir area of the two dams are bisected by rock discontinuities (e.g. joints, layering, bedding, fractures) which may cause the slope to fail once they day light. Failure may by induced by ground shaking, fluctuation of water level within the reservoir, or increase in hydrostatic pressure.

In spite of the all these, no detailed geological investigation was conducted on the two dam sites and tunnel corridor, nor to address the volume of debris deposited at the valley floor during and after the feasibility study stage of the project.

It should also be stressed at this point, that location of the power plant and other appurtenant structures also warrants a detailed geological study.

Extent of degradation affecting the slope sections at the headwater of Bonga River upstream from the Nueva Era Dam Site.

Photo shows section of the Abra – Ilocos Norte Road at the background showing damage while still under construction due to lateral movement.

Extent of sediment accumulation on the valley floor of Bonga River due to degradation at the headwater


Extent of degradation at the headwater of Bonga River upstream of the Nueva Era Dam Site

Photos taken in August 2019 (left) and April 2019 (right) showing displacement on the tension cracks present at the ridge crest separating Ilocos Norte from Abra. The Abra – Ilocos Norte Road at the background showing widening of gaps in the concrete slab joints signs of lateral movement

## 1.4 PROJECT ALTERNATIVES

In formulating the alternatives for the project, one of the basIs should be the result of a detailed geological investigation of the proposed dam sites and tunnel corridor. The massive degradation at the headwater of Bonga River that cause massive siltation due to deposition of slide debris upstream of Nueva Era Dam should be recognized as a direct threat to the life of the dam thus requires direct and unequivocal attention. The cause of the degradation and the possible solution also falls within and will be influenced by the geologic, tectonic and seismic conditions that will affect the two dam sites and tunnel corridor.

Addressing the degradation and its consequential result is not covered by the original Feasibility Study (FS) and said original FS is the basis for this EIA Study.

The coverage of the suggested detailed geological study should include the following;

1) Detailed Geological Mapping of the 2 Dam Sites, Debris Impounding Dam Site and Tunnel Corridor including Proposed Dam Relocation Sites if relocation is warranted. The detailed geological survey will be using site specific topographic maps from radar imaging, lidar imaging, and topographic mapping of the study site. The detailed geologic study will provide the following results:

    - Location of the position of Abra River Fault and other active faults in the vicinity vis-à-vis the 2 Dam Sites (including the location of possible relocation site if so needed), Tunnel Corridor, and Proposed Debris Impounding Dam
    - Fault Mapping and Characterization to establish the relationship, sense of movement, rate of displacement and direction of movements of the known active faults (primary faults) and lineaments, splays and / or branches (secondary faults).
    - Seismicity / Earthquake magnitude of known near site active faults
    - Site Specific Probabilistic Seismic Hazard Assessment
    - On site georesistivity survey (locate continuity of fault lines / shear zone across valley floor)
    - Trenching and paleo seismicity mapping (if applicable)

2) Seismicity study focused on site specific Probabilistic Seismic Hazard Assessment, identificationof potential earthquake generators, site specific earthquake magnitude, and the resulting Maximum Design Earthquake (MDE), Maximum Credible Earthquake (MCE) and Operational Basis Earthquake (OBE), historical earthquake, site specific seismic coefficients.

3) Geotechnical Drilling with required laboratory test following acceptable standards and Evaluation

4) Reservoir Slope Stability Analysis with detailed geological mapping, identification of slide zone, and determination of volume of slide materials

5) Slope and River Sectioning

6) Modeling of the wave that can be generated by land slide within the reservoir

7) Modelling of the resultant flood from overtopping of the dam

8) Seismic Load on Slopes (Dam Reservoir and Debris Impounding Structure)

9) Detailed geological mapping of the degradation zone on the headwater of Bonga River with Georesistivity Survey, Debris Volume Computation, Debris Flow Modelling and Debris Flow Velocity, and River Accretion Modeling

10) Detailed Geological Mapping of Service Area using Aerial Photo Interpretation, Quaternary Geological Mapping (Auger Drilling and Lithological Mapping of Deposition Zones identified geomorphic units, groundwater level / depth and Monitoring, Topographic Mapping and Georesistivity Survey

11) Option Building and Identification of Project Alternatives based on the results of the Detailed Geological Investigation covering;
    - Site Selection (Dam Relocation Sites, Tunnel Corridor, Power Plant Site and Appurtenant Structures, Debris Impounding Structure)
    - Type of Debris Impounding Structure
    - Dam Options for Nueva Era and or Palsiguan
    - Tunnel Options including that of the power plant

12) Value Engineering/Value Analysis is suggested since the additional study was not considered and undertaken during the feasibility study stage of the project. However, it may be considered under or the main activities for the “Pre-Detailed Engineering Design phase of the project” thus will be a major input in the Detailed Engineering Design Phase.

    Value Engineering / Value Analysis (VE/VA) in the selection of the best possible implementation / project options /configurations for the project (including new available technology which can be used to deliver the project or component/s of the project if present), to ensure that the best scheme be selected, which would yield the highest value-for-money (VfM). It is defined by the Society of American Value Engineers International (SAVE International), is the systematic application of recognized techniques by a multidisciplined team that identifies the functions of a product or service; establishes a worth for that function; generates alternatives through the use of creative thinking; and provides the needed functions, reliably at the lowest cost.

    VE/VA is a measure implemented by NEDA to subject major projects to ensure that projects/programs achieve full functionality at the most appropriate design and least project cost. This is in pursuit of the Philippine Government for a cost-efficient and cost-effective measures that support fiscal discipline and economic growth.

### 1.4.1 Comparison Based on Rice Production

The existing situation of ricelands and rice production will be continued in the no project option. Comparing the two alternatives, there will be significant changes in the manner of watering the rice lands as follows:

Table 3: Change in cropping pattern

| TYPE OF WATERING SYSTEM | NO. HA | CAV/HA | TOTAL CAV | CHANGE (CAV) |
|---|---|---|---|---|
| **WET SEASON** | | | | |
| **No Project Alternative (continue existing)** | | | | |
| **Rainfed Rice** | 1,294.00 | 44.00 | 56,936.00 | |
| **Irrigated Rice (gravity)** | 110.00 | 72.00 | 7,920.00 | |
| **Irrigated Rice (pump)** | 96.00 | 72.00 | 6,912.00 | |
| **TOTAL** | | | 71,768.00 | |
| | | | | **With Project Alternative** |
| **Irrigated Rice (project)** | 1,500.00 | 90.00 | 135,000.00 | |
| **TOTAL** | | | 135,000.00 | 63,232.00 |
| **DRY SEASON** | | | | |
| **No Project Alternative (continue existing)** | | | | |
| **Irrigated Rice (Gravity)** | 110.00 | 76.00 | 8,360.00 | |
| **Irrigated Rice (Pump)** | 96.00 | 76.00 | 7,296.00 | |
| **TOTAL** | | | 15,656.00 | |
| | | | | **With Project Alternative** |
| **Irrigated Rice (Project)** | 1,500.00 | 100.00 | 150,000.00 | |
| **TOTAL** | | | 150,000.00 | 134,344.00 |
| | | | | 197,576.00 |

The no-Project alternative means that 86.2 % of the rice lands in the municipality of Lopez will continue to be have only one cropping per year while the rest of the rice lands with a semblance of an irrigation system will produce rice at a lower rate than that for a fully irrigated systems. This will result in a net opportunity loss of up to 200,000 cav (rounded off) of rice a year which is enough productivity to feed the population of Lopez and its projected population increase for the next 5 to 10 years.

### 1.4.2 Comparison based on labor requirements

The Project will also cause the use of more farm labor because of the additional cropping. This is explained in detail in the following table.

Table 4: Labor Requirements

| TYPE OF WATERING SYSTEM | LAND AREA, HA | UNIT EFFORT, PAX-DA/HA | TOTAL EFFORT, PERSON DAYS | CHANGE, PAX-DA |
|---|---|---|---|---|
| **WET SEASON** | | | | |
| **No Project Alternative (continue existing)** | | | | |
| **Rainfed Rice** | 1,294.00 | 68.00 | 87,992.00 | |
| **Irrigated Rice (gravity)** | 110.00 | 80.00 | 8,800.00 | |
| **Irrigated Rice (pump)** | 96.00 | 80.00 | 7,680.00 | |
| **TOTAL** | | | 104,472.00 | |
| **With Project Alternative** | | | | |

| | | | | |
|---|---|---|---|---|
| **Irrigated Rice (Project)** | 1,500.00 | 72.00 | 108,000.00 | |
| **TOTAL** | | | 108,000.00 | 3,528.00 |
| **DRY SEASON** | | | | |
| **No Project Alternative (continue existing)** | | | | |
| **Irrigated Rice (gravity)** | 110.00 | 89.00 | 9,790.00 | |
| **Irrigated Rice (pump)** | 96.00 | 89.00 | 8,544.00 | |
| **TOTAL** | | | 18,334.00 | |
| **With Project Alternative** | | | | |
| **Irrigated Rice (Project)** | 1,500.00 | 85.00 | 127,500.00 | |
| **TOTAL** | | | 127,500.00 | 109,166.00 |
| | | | | 112,694.00 |

Up to 113,000 person-days of anticipated additional farm labour will not be realized if the project does not push through, which translates to roughly PhP19.325 million in foregone wages if one uses an average of PhP150 paid per person-day for agriculture-based work. Hence, the project will not only contribute to the food security of the region but also increase employment among agricultural workers in the area.

### 1.4.3 Comparison based on Infrastructure

Without the project, no areas will be inundated, and no new roads will be built at least within the next three years. Currently, the proposed dam site is reachable by a 3 km dirt road from the nearest (newly opened) paved barangay road. There are limited transportation routes into the farms with motorcycles and farm equipment used as vehicles. With the project, gravel roads will be built along the main canal length and along lateral canals and an access road will be built that will allow equipment to reach the dam site from the paved barangay road. Likewise, about 236.6 ha of land will be inundated based on normal reservoir height if the project is finished. The summary is as follows:

Table 5: Infrastructure Comparison

| DETAILS | WITH THE PROJECT | WITHOUT THE PROJECT |
|---|---|---|
| **Inundated area for reservoir** | 236.6 ha will be inundated | No inundation |
| **Dam** | height of 16.83 m, crest of 270 m | None, no dam to be constructed |
| **Main Canal** | 21.02 km | Parts of the canal are already existing, but these will be improved |
| **Gravel roads adjacent to main canal** | 21.02 km | None |
| **Lateral Canals** | 23.05 km | None |
| **Gravel roads** | 23.05 km | None |
| **Access Road to Dam Site** | 3 km paved | 3 km dirt |

## 1.5 PHYSICAL PROJECT COMPONENTS

INIP-2 is designed as a multipurpose development project which comprises, among others: (i) dam and reservoir and (ii) irrigation and drainage as its major components.

The project involves the construction of a 126.41-meter-high earth and rockfill dam across Palsiguan River, within the municipality of Lagayan, Province of Abra of the Cordillera Autonomous Region. The dam's geographical position is at Latitude 17°49'34.28"N and Longitude 120°43'50.35"E. An approximately 147 million cubic meter (M $m^3$) of water shall be stored in the reservoir for efficient delivery and multipurpose utilization.

A 6.15-km headrace tunnel and a 2.95-km tailrace tunnel shall deliver the aforementioned water requirement from an intake structure to be located at the mid- portion of the reservoir area.

For the power component of the Project, hydropower facilities shall be provided at each outlet of the tunnels, the 14 MW Bonga power station and the 6.8 MW Nueva Era power station, capable of generating annually 82.18 GWh and 39.50 GWh, respectively.

With regards to the irrigation component, the Nueva Era afterbay dam shall serve as the re-regulating structure in the delivery of irrigation water to the 3,572 has of the INIP-1 area: a) Labogaon, b) Solsona, c) Madongan, d) Papa and, e) Nueva Era National Irrigation Systems (NISs), through the 38.395-km Link Canal No. 1.

While the 24.872-km of Link Canals designated as Nos 2 & 3 shall provide irrigation water to the 11,100-ha of the INIP-2 area: a) Batac-Paoay, b) Badoc-Sinait, c) Pinili, d) Madupayas and e) Nueva Era-left bank.

Table 6 is a summary of major project components and the corresponding features.

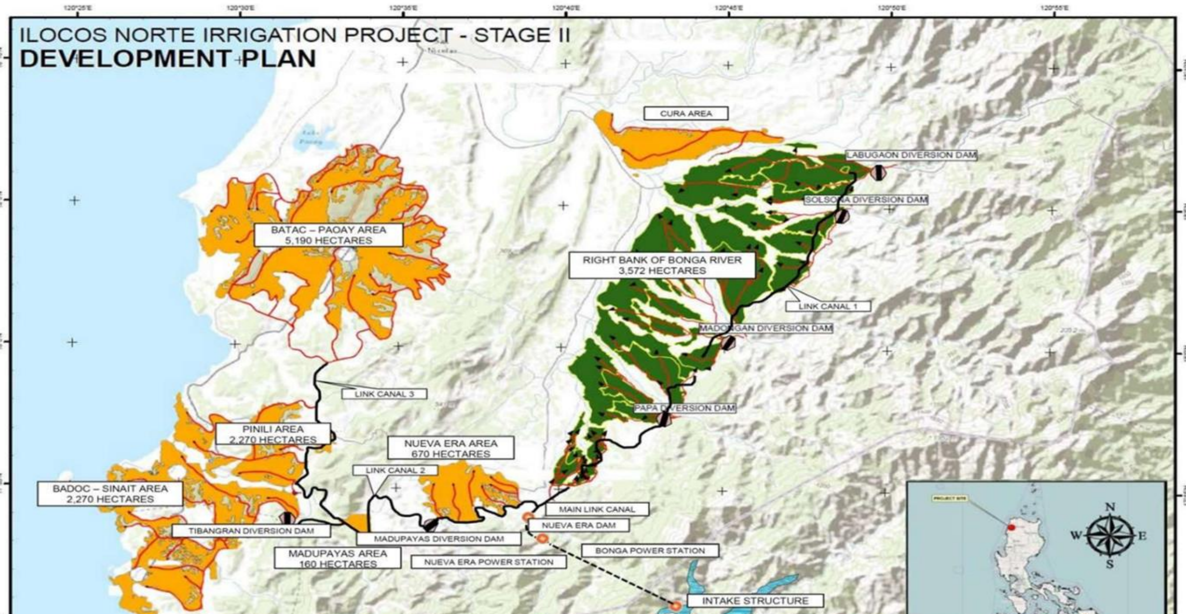



Figure 2: Development Plan of the Ilocos Norte Irrigation Project – Stage II

Table 6: Major Project Components and Features

| PROJECT COMPONENTS | FEATURES |
|---|---|
| Palsiguan Dam | |
| **Site location** | 17°49'34.28"N, 120°43'50.35"E |
| **Catchment Area** | 153.00 $km^2$ |
| **Dam Type** | earth and rockfill dam |
| **Dam Height** | 126.41 m |
| **Total Capacity** | 147 M $m^3$ |
| **Embankment Volume** | 9,100,000.00 cu.m. |
| **Spillway Capacity** | 3,070.00 $m^3$/sec |
| **Diversion Works**<br>**Tunnel Length**<br>**Discharge** | <br>740.00 m<br>950.00 $m^3$/sec |
| Headrace Tunnel | |
| **Site location (intake)** | 17°53'5.07"N, 120°41'10.82"E |
| **Length** | 2,950.00 m |
| **Capacity** | 28.225 $m^3$/ sec |
| Nueva Era Afterbay Dam | |
| **Site location** | 17°53'30.15"N, 120°39'48.20"E |
| **Dam Type** | Concrete dam |
| **Dam Height** | 45.50 m |
| **Storage Capacity** | 5.73 M $m^3$ |
| **Effective Capacity** | 1.17 M $m^3$ |
| Hydropower Plants | |
| **Installed Capacity**<br>**Bonga Station**<br>**Nueva Era Station** | <br>14,000 KW<br>6,800 KW |
| **Annual Energy Production**<br>**Bonga Station**<br>**Nueva Era Station** | <br>82.18 GWh<br>39.50 GWh |
| Irrigable Service Area | |
| **Nueva Era area (left bank)** | 670 ha |
| **Madupayas area** | 160 ha |
| **Batac-Paoay area** | 5,190 ha |
| **Pinili area** | 1,400 ha |
| **Badoc-Sinait area** | 2,270 ha |
| Sub-total (INIP-2 area) | **11,1000 ha** |
| Sub-total (INIP-1 area) | **3,572 ha** |
| **TOTAL SERVICE AREA** | **14,672 ha** |

### 1.5.1 Dam and Appurtenant Structures

The proposed dam is envisioned to be constructed across the Palsiguan River in the municipality of Lagayan in the province of Abra having geographical coordinates of 17° 49’ 34” N and 120° 43’ 50.50” E. The dam would be of the earth and rock-fill type, about 143.50-m high, 480.00-m long and 10- m wide crest. The upstream and downstream embankment slopes would be 2.8:1 and 1.9:1, respectively.

**Dam Height**

The damsite is located in the municipality of Lagayan, province of Abra. The height of dam depends on the topography of the area and the reservoir volume that adequately satisfy the intended needs of the Project. A freeboard will be added to the height of the dam to take care of the rise in the reservoir water due to wave action, etc.

Freeboard and Crest Elevation of Dam. Freeboard is the difference between the crest elevation and the full water surface level in a reservoir. Freeboard should be greater than or equal to the sum of the surcharge height, height of wave due to wind, height of wave due to earthquake and contingency height. The surcharge height is taken as the corresponding height of the peak inflow of the design flood. Height of wave due to wind was derived from factors such as fetch and wind speed. The Molitor-Stevenson formula was used to determine the height of wave due to wind. Since uprushing height varies considerably with embankment slope and roughness of slope, height of significant wave should be adjusted adequately.

The dam crest elevation was obtained by adding the freeboard and full water surface. The crest will be used as maintenance road so an additional height is included. The Dam Crest Elevation was set at elevation 329.50 masl.

**Axis Alignment**

The dam would be across Palsiguan River in the municipality of Lagayan in the province of Abra. The abutments along the selected axis and in the immediate riverbed vicinity have steep slope banks. The ground contours almost parallel to the river alignment without major morphological variations.

**Dam Embankment**

For the dam structure to attain the requisite degree of imperviousness, the mid-section or central core would be composed of clayey materials. A downstream sand and gravel filter drain would be placed directly adjacent to the clayey central core with its horizontal segment extending up to the boulder toe drain.

To provide additional structural stability and more protection to the impervious zone, an outer shell composed of rocks and boulders will be provided. These materials are readily available within the project area.

**Foundation**

The area under the dam body is stripped to a minimum depth of 1.0 m and to a depth where organic materials are present. The dam foundation excavation lines in particular under the core trench is essentially up to the sound rock strata. The depth of inferred sound rock strata is about 14 m. Overburden materials are stiff to very dense transported and residual soil.

**Excavation Level**

The level down to which it will be necessary to carry the foundation excavation for each of the sections of the dam will vary according to the position of the rock strata and state of weathering.

Fully weathered layers will have to be removed from the foundation areas since these are mechanically weak and potentially semi-pervious. The final excavation levels would be determined upon visual inspection during excavation at construction time.

The sound, defined as the hard rock limiting surface for mechanical excavation, must be reached. The sound rock once exposed will have to be cleaned by hand excavation and air and water jets. The main purpose of the cleaning is to remove the filling from the joints especially from those joints crossing the axis at angles 90 degrees.

**Cofferdam**

The river waters will be diverted into the diversion conduit by means of cofferdam. The cofferdam embankment will consist of a homogenous material with slopes 2.8:1 on the upstream side and on the downstream side the slope is 1.9:1. The cofferdam will be incorporated into the main dam body.

It is anticipated that part of the embankment materials would come from the dam and spillway excavations. The cofferdam will divert river's low water flow and the 10-yr inflow design flood into the diversion conduit.

**Spillway**

Various combinations of flood storage and spillway lengths and capacities were investigated. These investigations required flood routings, spillway layouts and estimates. An un-gated structure was chosen for its ability to function under the least maintenance cost- and trouble-free operation.

The hydraulic size and outflow characteristics of the spillway were determined by routing the inflow design flood with a return period of 200 years. The specific dimensions for the spillway were developed considering the topography and foundation conditions.

The ungated spillway that is made of class "A" reinforced concrete has an ogee type weir having a crest length of 75 m and crest at elevation 317.60 m and is located on the right abutment. This is designed to safely permit the passage of the routed maximum flood. The spillway is so aligned in order that it would discharge directly to the river streambed. The inclined chute will terminate with a Type II stilling basin having a width of 75 m and a length of 40 m. The high-water velocities and large pressures would need to be controlled to avoid detrimental scour, erosion or damage to adjacent structures. Construction of the spillway would require a deep cut excavation and the large volume of excavation would be used for the dam embankment.

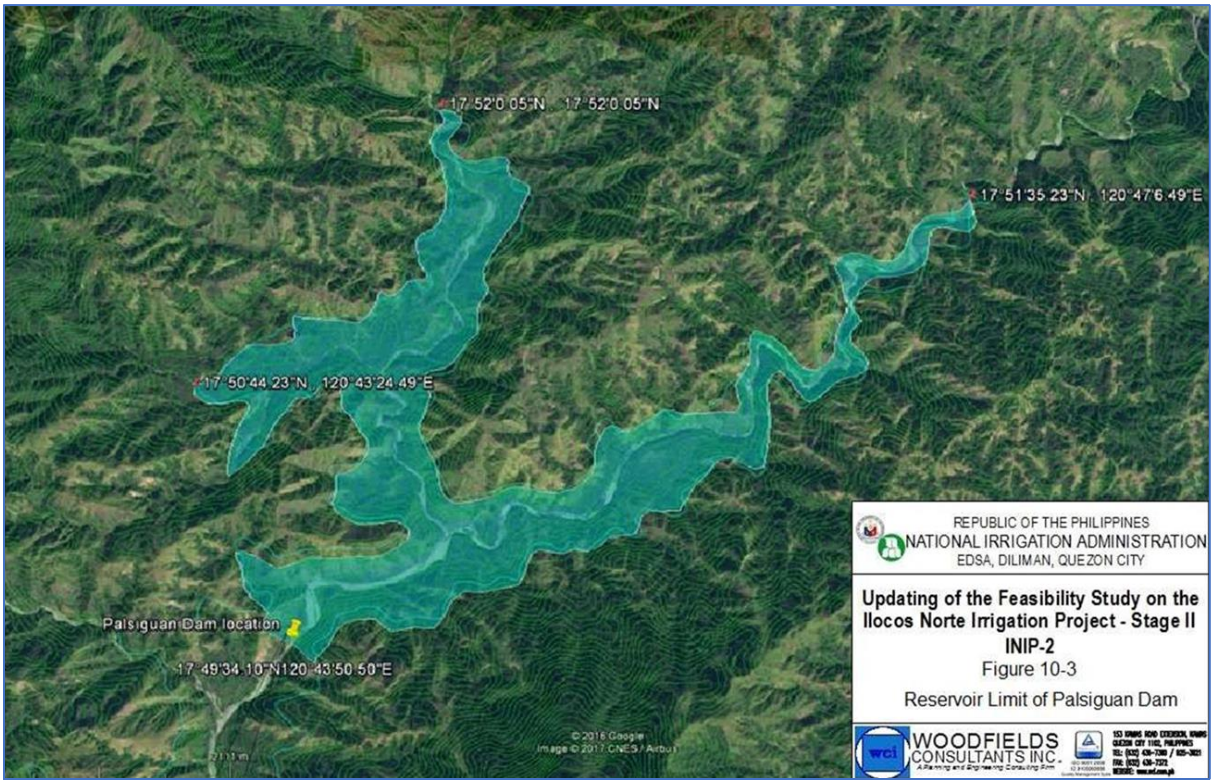
**Diversion during Construction**

The selection of the size and number of diversion conduit is dependent on the height of the cofferdam, i.e., size of the diversion conduit is inversely proportional to the adopted design head. Several dimensions and combinations have been tried that aim to minimize or optimize the overall cost of the diversion works as well as the constraints on implementation methods and schedule.

To divert river flows during construction, two barrels of concrete conduit having a dimension of 5 m each will be constructed. The diversion conduit in combination with the planned cofferdam would protect civil works construction structures and equipment against the 10-year flood frequency.

**Dam Instrumentation**

To monitor the condition of the dam, an extensive package of instruments will be installed in the dam body during construction. These would monitor settlements, deformation, pore pressures and total loads or pressure within the various elements of the structures. The instrumentation package would include piezometers, inclinometers, internal movement and strain gauges, total pressure cells, settlement gauges and surface monuments.




### *1.5.1.1. Nueva Era Dam*

The proposed afterbay dam is envisioned to be constructed across the Bonga River in the municipality of Nueva Era in the province of Ilocos Norte having geographical coordinates of 17° 53' 20.21" N and 120° 39' 49.59" E. The dam location is about 1.50 km south of Nueva Era town in aerial distance. The dam would be of the concrete gravity type, about 45 m high from the riverbed.

**Axis Alignment**

The dam is located in the municipality of Nueva Era, Ilocos Norte. The abutments along the selected axis and in the immediate riverbed vicinity have moderate slope banks. The ground contours almost parallel to the river alignment without major morphological variations.

**Concrete Gravity Dam**

The gravity dam would have an overflow section serving as the spillway and a non-overflow section. The ogee in the overflow section would be 45.00 m above the streambed and this is at elevation 186.82 masl. The top of the dam of the bridge deck is at elevation 193.82 masl. From the top of the ogee to the bottom of the bridge deck girder has a clear height of 7 m. The length of dam crest is about 213 m. The total width of the dam at bed rock from heel to toe is around 77 m. In the central portion of the dam is the spillway with a total clear width of 60.00 m. The spillway would consist of 5 bays having a clear span of 12.00 m and each bay would have 1.50 m thick reinforced concrete piers.

The usual instrumentation of the concrete dam is the observation of level of seepage that may occur either through the foundation grout curtain, through the interface between the foundation surface and the concrete or through the concrete in between lifts. These can be monitored by installing PVC standpipes from the concerned area as mentioned then will exit to the drainage gallery, where seepage or water level inside the standpipe can be monitored.

**Foundation**

The area under the dam body is stripped to a minimum depth of 1.0 meter and to a depth where organic materials are present. The dam foundation excavation lines are essentially up to the sound rock strata. The inferred sound rock strata have been assumed to be 14.5 m in depth. Overburden materials are stiff to very dense transported and residual soil.

**Excavation Level**

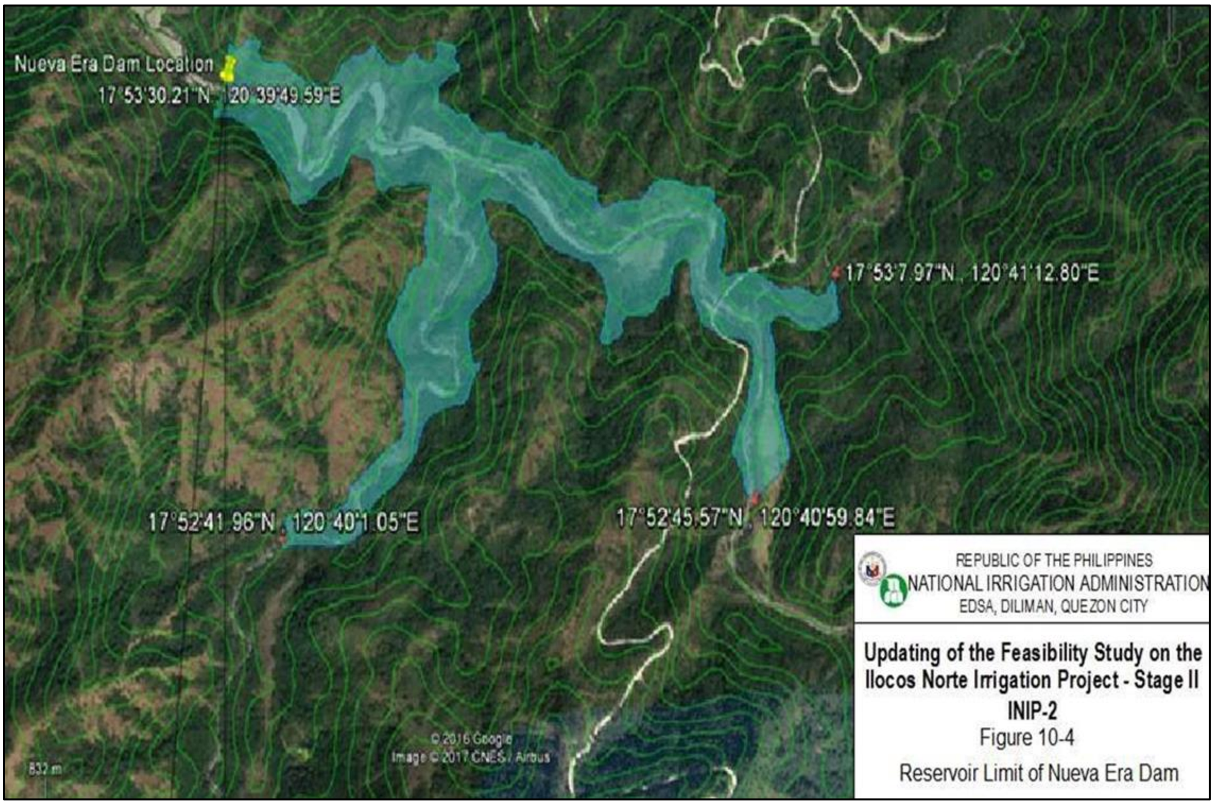
The level down to which it will be necessary to carry the foundation excavation for each of the sections of the dam will vary according to the position of the rock strata and state of weathering.

Fully weathered layers will have to be removed from the foundation areas since these are mechanically weak and potentially semi-pervious. The final excavation levels would be determined upon visual inspection during excavation at construction time.

The sound, defined as the hard rock limiting surface for mechanical excavation, must be reached. The sound rock once exposed will have to be cleaned by hand excavation and air and water jets. The main purpose of the cleaning is to remove the filling from the joints especially from those joints crossing the axis at angles 90 degrees.

**Reservoir**

In a multipurpose river project, clearing of the reservoir is essential to its operation. Prevailing winds and watershed flow conditions move trees, logs and other debris to the shoreline and outlets of the reservoir. Under extreme flood conditions with high flows passing through the spillway, large trees and other floating debris could plug the spillway to a certain degree, thereby reducing the spillway outflows to a point of endangering the safety of the dam. In this respect, the project plans anticipate the removal of all trees, brushes and other structures below the top of the maximum water surface elevation of 192.27 m down to 2 m below the minimum reservoir water surface level of 167.18 m.




## 1.5.2. Hydropower

### *1.5.2.1. Palsiguan*

This development complex starts from the 139.5-meter-high Palsiguan Dam to be built across the Palsiguan River with a storage capacity of about 189 M $m^3$ for both irrigation and power generation. This capacity in combination with proper reservoir operation as required for irrigation will make available a daily discharge of about 13.64 $m^3$/sec. Drainage area at the damsite is about 153 $km^2$ of forest land that catches a mean actual rainfall of 2,600 mm.

Runoff from this rainfall will be transported through a trans-basin tunnel about 6,150 m long and 2.6 m in diameter into the next component of the development where it will end up in an underground surge shaft. From the surge shaft, water will be conducted into the penstock that slopes toward the underground powerplant, the Bonga River HE Plant.

### *1.5.2.2. Bonga River Hydro-Electric Plant*

The Bonga river hydropower plant will receive the 13.64 CMS from Palsiguan Dam and in combination with a rated effective head of about 149.3 m will generate a capacity of 36,000 kW and an annual energy of about 159.66 GWH. The Powerplant will be about 70 m underground where the only access to the plant will be a shaft directly above the powerhouse.

From the powerplant, water will again be conducted though a tailrace tunnel about 2,950 m long whose diameter is to be a little bit larger to allow for a free-flowing conduit. This tailrace tunnel will end up into the reservoir of the Nueva Era Dam.

#### *1.5.2.3. Nueva Era*

The Nueva Era Dam will take advantage of the 13.64 CMS Palsiguan Dam yield after generating at the Bonga Hydropower Plant. Adding its own yield of 4.37 CMS, an equivalent total daily flow of 18.01 CMS will be made available.

Capacity of the Nueva Era powerplant however, will be measured from the maximum requirement for irrigation which is 29.273 $m^3$/sec and together with an effective head of about 27.92 m will result in a capacity of 6,800 kW. This capacity will generate an annual energy of 39.54 GWh

The total capacity of the Palsiguan-Bonga-Nueva Era Complex will therefore be 42,800kW with a total energy generation of about 199.2 GWh.

The hydropower plant will be located directly at the foot of the concrete gravity Nueva Era dam which will have a height of about 45.50 m and a crest length of about 220 m.

### 1.5.3. Irrigation and Drainage

#### *1.5.3.1. Irrigation Canals*

**Objective Canals**

The service area of the Project was 3,576.00 and 11,100.00 ha for the total of 14,676.00 ha for Link Canal 1 and Link Canal 2 & 3 and applied unit water demand (design waterduty) for the design of canals is 1.84 li/sec-ha, and 1.76 li/sec-ha, respectively. The irrigation works of canal sections and its details of canal works are presented in Table.

Table 7: List of Designed Irrigation Canals

| CANAL | STATIONING | TYPE | LENGTH | REMARKS |
|---|---|---|---|---|
| **Link Canal 1** | 0+000.00 | 38+395.38 | 38.861 km. | **Proposed Lined Canal** |
| **Link Canal 2 & 3** | **0+000.00** | **24+872.00** | **24.872 km.** | **Proposed Lined Canal** |

**Canal Type**

The proposed Lined Canal consists of (3) types to suit the present condition of the project area. Type I is a Rectangular Lined Section of 20 cm. thick reinforced concrete, Class "B" (f'c = 170 kg/$cm^2$) with 12 mm diameter RSB, spaced at 150 mm both ways. This type is applied to Link Canal 1 and Link Canal 2 & 3 and provided with (300 mm x 150 mm) concrete stiffeners spaced for every 5.00 m. interval. Type II is a Rectangular Lined Section of 15 cm. and 10 cm. thick reinforced concrete, Class "B" (f'c = 170 kg/$cm^2$ with 12 mm diameter RSB, spaced at 150 mm both ways. This type is applied to Main Canals with the height (H) is more than 1.00 m. and provided with (300 mm x 150 mm.) concrete stiffeners spaced for every 5.00 m. interval. Type III is a Rectangular Lined Section of 10 mm thick reinforced concrete, Class " B " (f'c = 170 kg/$cm^2$) with 10 mm diameter RSB, spaced at 300 mm both ways. This type is applied to Main Canals and Lateral Canals with the height (H) is less than 1.00 m and provided with (200 mm x 150 mm) concrete stiffeners spaced for every 5.00 m interval.

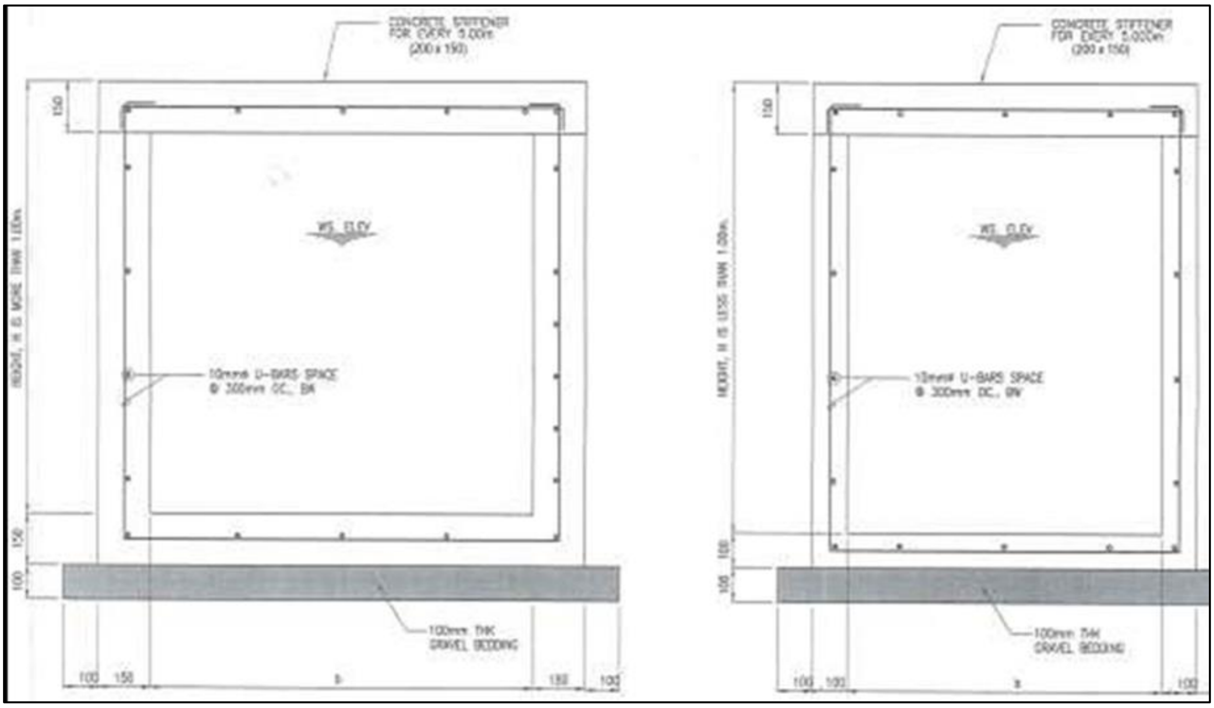


Figure 3: Typical Canal Section

Design discharge and hydraulic calculations design discharge of each canal section is simply calculated based on the irrigation command area and unit diversion discharge as practiced by the Irrigation Management Office (IMO).

The hydraulic calculations were computed following the NIA guidelines and criteria for hydraulic canal elements manning's formula was considered as stated below.

$$V = \frac{1}{n} (R^{2/3}) (S^{1/2})$$

Where: ...........................................................................................................................

$V$ = mean velocity of flow in canal, m/s
$n$ = Manning's roughness coefficient
$R$ = hydraulic radius
$S$ = hydraulic gradient

For roughness coefficient *n* a value of 0.018 was considered for concrete lining for hydraulic gradient *S* the slope of canal was based on the field condition. In case the computed velocity is more the maximum or less than the maximum or less than the maximum; the hydraulic gradient may be adjusted to meet the permissible velocity. Maximum permissible velocity of 2.00 m/s and minimum permissible velocity is 0.30 m/s were adopted. For calculation the hydraulic radius *R*, cross-sectional area *A* and wetted perimeter *P* were computed using the formula *A/P* considering the ratio of b = d and canal side slope 0:1 for Rectangular Lined Canal were adopted. Criteria of flow depth *d* up to 2.00 m. was also considered, however maximum computed " d " for this Project is more than 2.00 m. Freeboard, FB = 0.25d + 0.30 m. for depths of flow more than 2.00 m.

Table 8: Hydraulic Design of Canal Elements
Link Canal 1

| | | DISTANCE | Q | V | A | b | d | D | R | P | s | ss | n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FROM | TO | | $m^3$/sec | m/s | $m^2$ | m | m | m | m | m | | (H:1) | |
| 0+000.00 | 0+577.30 | 577.30 | 0.0000 | 0.795 | 8.280 | 4.10 | 2.02 | 2.80 | 1.017 | 8.139 | 0.00020 | 0 | 0.018 |
| 0+577.30 | 0+740.00 | Closed Conduit ( 1-1.60 m. x 1.40 m.-Existing ) | | | | | | | | | | | |
| 0+740.00 | 0+930.00 | 190.00 | 0.0000 | 0.795 | 8.280 | 4.10 | 2.02 | 2.80 | 1.017 | 8.139 | 0.00020 | 0 | 0.018 |
| 0+930.00 | 1+075.00 | Closed Conduit ( 1-1.60 m. x 1.40 m.-Existing ) | | | | | | | | | | | |
| 1+075.00 | 1+140.00 | 65.00 | 0.0000 | 0.795 | 8.280 | 4.10 | 2.02 | 2.80 | 1.017 | 8.139 | 0.00020 | 0 | 0.018 |
| | 1+140.00 | Comb. Road x-ing,Check and Headgate of Nueva Era M.C. ( Existing ) | | | | | | | | | | | |
| 1+140.00 | 1+285.00 | 145.00 | 0.0000 | 0.787 | 8.032 | 4.00 | 2.01 | 2.80 | 1.002 | 8.016 | 0.00020 | 0 | 0.018 |
| | 1+285.00 | Road x-ing ( Existing ) | | | | | | | | | | | |
| 1+285.00 | 1+600.00 | 315.00 | 0.0000 | 0.787 | 8.032 | 4.00 | 2.01 | 2.80 | 1.002 | 8.016 | 0.00020 | 0 | 0.018 |
| | 1+600.00 | Road x-ing ( Existing ) | | | | | | | | | | | |
| 1+600.00 | 2+270.00 | 670.00 | 0.0000 | 0.787 | 8.032 | 4.00 | 2.01 | 2.80 | 1.002 | 8.016 | 0.00020 | 0 | 0.018 |
| | 2+270.00 | Check Structure with T.O. # 3 , 4 L/S & T.O. # 5 R/S | | | | | | | | | | | |
| 2+270.00 | 2+940.00 | 670.00 | 0.0000 | 0.785 | 7.971 | 4.00 | 1.99 | 2.80 | 0.998 | 7.986 | 0.00020 | 0 | 0.018 |
| | 2+940.00 | Check Structure with T.O. # 7 L/S | | | | | | | | | | | |
| 2+940.00 | 3+430.00 | 490.00 | 0.0000 | 0.783 | 7.927 | 4.00 | 1.98 | 2.80 | 0.995 | 7.964 | 0.00020 | 0 | 0.018 |
| | 3+430.00 | Road x-ing | | | | | | | | | | | |
| 3+430.00 | 4+743.00 | 1313.00 | 0.0000 | 0.783 | 7.927 | 4.00 | 1.98 | 2.80 | 0.995 | 7.964 | 0.00020 | 0 | 0.018 |
| | 4+743.00 | Road x-ing with Check | | | | | | | | | | | |
| 4+743.00 | 5+188.00 | 445.00 | 0.0000 | 0.783 | 7.908 | 4.00 | 1.98 | 2.80 | 0.994 | 7.954 | 0.00020 | 0 | 0.018 |
| | 5+188.00 | Road x-ing | | | | | | | | | | | |
| 5+188.00 | 5+632.00 | 444.00 | 0.0000 | 0.783 | 7.908 | 4.00 | 1.98 | 2.80 | 0.994 | 7.954 | 0.00020 | 0 | 0.018 |
| | 5+632.00 | Road x-ing with Check | | | | | | | | | | | |
| 5+632.00 | 6+000.00 | 368.00 | 0.0000 | 0.781 | 7.857 | 4.00 | 1.96 | 2.75 | 0.991 | 7.928 | 0.00020 | 0 | 0.018 |
| | 6+000.00 | Check Structure with T.O. # 16 L/S | | | | | | | | | | | |
| 6+000.00 | 7+700.00 | 1700.00 | 0.0000 | 0.780 | 7.838 | 4.00 | 1.96 | 2.75 | 0.990 | 7.919 | 0.00020 | 0 | 0.018 |
| | 7+700.00 | Road x-ing | | | | | | | | | | | |
| 7+700.00 | 8+300.00 | 600.00 | 0.0000 | 0.780 | 7.838 | 4.00 | 1.96 | 2.75 | 0.990 | 7.919 | 0.00020 | 0 | 0.018 |
| | 8+300.00 | Inclined Drop | | | | | | | | | | | |
| 8+300.00 | 8+656.54 | 356.54 | 0.0000 | 0.780 | 7.838 | 4.00 | 1.96 | 2.75 | 0.990 | 7.919 | 0.00020 | 0 | 0.018 |
| | 8+656.54 | Road x-ing with Drop | | | | | | | | | | | |
| 8+656.54 | 10+385.23 | 1728.69 | 0.0000 | 0.780 | 7.838 | 4.00 | 1.96 | 2.75 | 0.990 | 7.919 | 0.00020 | 0 | 0.018 |
| | 10+385.23 | Road x-ing | | | | | | | | | | | |
| 10+385.23 | 10+697.26 | 312.03 | 0.0000 | 0.780 | 7.838 | 4.00 | 1.96 | 2.75 | 0.990 | 7.919 | 0.00020 | 0 | 0.018 |
| | 10+697.26 | Road x-ing | | | | | | | | | | | |
| 10+697.26 | 10+968.93 | 271.67 | 0.0000 | 0.780 | 7.838 | 4.00 | 1.96 | 2.75 | 0.990 | 7.919 | 0.00020 | 0 | 0.018 |
| | 10+968.93 | Road x-ing | | | | | | | | | | | |
| 10+968.93 | 11+192.27 | 223.34 | 0.0000 | 0.780 | 7.838 | 4.00 | 1.96 | 2.75 | 0.990 | 7.919 | 0.00020 | 0 | 0.018 |
| | 11+192.27 | Road x-ing with Check & T.O. # 17 L/S to serve Papa Left Main Canal | | | | | | | | | | | |
| 11+192.27 | 11+395.66 | 203.39 | 0.0000 | 0.759 | 7.214 | 3.80 | 1.90 | 2.65 | 0.950 | 7.597 | 0.00020 | 0 | 0.018 |
| 11+395.66 | 11+576.75 | Siphon with Road x-ing at Inlet Transition | | | | | | | | | | | |
| 11+576.75 | 12+129.57 | 552.82 | 0.0000 | 0.759 | 7.214 | 3.80 | 1.90 | 2.65 | 0.950 | 7.597 | 0.00020 | 0 | 0.018 |
| | 12+129.57 | Check Structure with T.O. # 18 L/S to serve Papa Right Main Canal | | | | | | | | | | | |
| 12+129.57 | 12+443.51 | 313.94 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 12+443.51 | Road x-ing | | | | | | | | | | | |
| 12+443.51 | 12+481.69 | 38.18 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 12+481.69 | Road x-ing | | | | | | | | | | | |
| 12+481.69 | 12+955.09 | 473.40 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 12+955.09 | Road x-ing | | | | | | | | | | | |
| 12+955.09 | 13+379.80 | 424.71 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 13+379.80 | Road x-ing | | | | | | | | | | | |
| 13+379.80 | 13+785.17 | 405.37 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 13+785.17 | Road x-ing | | | | | | | | | | | |
| 13+785.17 | 14+541.17 | 756.00 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 14+541.17 | Road x-ing | | | | | | | | | | | |
| 14+541.17 | 15+089.45 | 548.28 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 15+089.45 | Road x-ing | | | | | | | | | | | |
| 15+089.45 | 15+850.00 | 760.55 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 15+850.00 | Road x-ing | | | | | | | | | | | |
| 15+850.0 | 16+257.88 | 407.88 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.0002 | 0 | 0.018 |

| | | DISTANCE | Q | V | A | b | d | D | R | P | s | ss | n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FROM | TO | | $m^3$/sec | m/s | $m^2$ | m | m | m | m | m | | (H:1) | |
| 0 | | | | | | | | | | | 0 | | |
| | 16+257.88 | Road x-ing | | | | | | | | | | | |
| 16+257.88 | 17+868.96 | 1611.08 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 17+868.96 | Road x-ing | | | | | | | | | | | |
| 17+868.96 | 18+359.83 | 490.87 | 0.0000 | 0.740 | 6.688 | 3.70 | 1.81 | 2.55 | 0.914 | 7.315 | 0.00020 | 0 | 0.018 |
| | 18+359.83 | Check Structure with T.O. # 19 L/S to serve Madongan Left Main Canal | | | | | | | | | | | |
| 18+359.83 | 18+983.45 | 623.62 | 0.0000 | 0.663 | 4.797 | 3.10 | 1.55 | 2.20 | 0.774 | 6.195 | 0.00020 | 0 | 0.018 |
| 18+983.45 | 19+375.00 | Siphon | | | | | | | | | | | |
| 19+375.00 | 19+635.93 | 260.93 | 0.0000 | 0.663 | 4.797 | 3.10 | 1.55 | 2.20 | 0.774 | 6.195 | 0.00020 | 0 | 0.018 |
| | 19+635.93 | Check Structure with T.O. # 20 L/S to serve Madongan Right Main Canal | | | | | | | | | | | |
| 19+635.93 | 19+672.16 | 36.23 | 0.0000 | 0.663 | 4.797 | 3.10 | 1.55 | 2.20 | 0.774 | 6.195 | 0.00020 | 0 | 0.018 |
| | 19+672.16 | Road x-ing | | | | | | | | | | | |
| 19+672.16 | 20+089.98 | 417.82 | 0.0000 | 0.646 | 4.453 | 3.00 | 1.48 | 2.10 | 0.746 | 5.969 | 0.00020 | 0 | 0.018 |
| | 20+089.98 | Road x-ing | | | | | | | | | | | |
| 20+089.98 | 24+612.03 | 4522.05 | 0.0000 | 0.646 | 4.453 | 3.00 | 1.48 | 2.10 | 0.746 | 5.969 | 0.00020 | 0 | 0.018 |
| | 24+612.03 | Road x-ing | | | | | | | | | | | |
| 24+612.03 | 34+888.59 | 10276.56 | 0.0000 | 0.646 | 4.453 | 3.00 | 1.48 | 2.10 | 0.746 | 5.969 | 0.00020 | 0 | 0.018 |
| | 34+888.59 | Road x-ing | | | | | | | | | | | |
| 34+888.59 | 35+056.75 | 168.16 | 0.0000 | 0.646 | 4.453 | 3.00 | 1.48 | 2.10 | 0.746 | 5.969 | 0.00020 | 0 | 0.018 |
| | 35+056.75 | Check Structure with T.O. # 21 L/S to serve Solsona Left Main Canal | | | | | | | | | | | |
| 35+056.75 | 35+465.04 | 408.29 | 0.0000 | 0.603 | 1.969 | 2.00 | 0.98 | 1.40 | 0.496 | 3.969 | 0.00030 | 0 | 0.018 |
| 35+465.04 | 35+719.03 | Siphon with Road x-ing at Inlet & Outlet Transition | | | | | | | | | | | |
| 35+719.03 | 35+741.95 | 22.92 | 0.0000 | 0.603 | 1.969 | 2.00 | 0.98 | 1.40 | 0.496 | 3.969 | 0.00030 | 0 | 0.018 |
| | 35+741.95 | Check Structure with T.O. # 22 L/S to serve Solsona Right Main Canal | | | | | | | | | | | |
| 35+741.95 | 36+000.00 | 258.05 | 0.0000 | 0.578 | 1.733 | 1.90 | 0.91 | 1.30 | 0.465 | 3.724 | 0.00030 | 0 | 0.018 |
| | 36+000.00 | Road x-ing | | | | | | | | | | | |
| 36+000.00 | 36+464.16 | 464.16 | 0.0000 | 0.578 | 1.733 | 1.90 | 0.91 | 1.30 | 0.465 | 3.724 | 0.00030 | 0 | 0.018 |
| | 36+464.16 | Road x-ing | | | | | | | | | | | |
| 36+464.16 | 37+000.00 | 535.84 | 0.0000 | 0.578 | 1.733 | 1.90 | 0.91 | 1.30 | 0.465 | 3.724 | 0.00030 | 0 | 0.018 |
| | 37+000.00 | Road x-ing | | | | | | | | | | | |
| 37+000.00 | 37+443.31 | 443.31 | 0.0000 | 0.578 | 1.733 | 1.90 | 0.91 | 1.30 | 0.465 | 3.724 | 0.00030 | 0 | 0.018 |
| | 37+443.31 | Road x-ing | | | | | | | | | | | |
| 37+443.31 | 37+785.01 | 341.70 | 0.0000 | 0.578 | 1.733 | 1.90 | 0.91 | 1.30 | 0.465 | 3.724 | 0.00030 | 0 | 0.018 |
| | 37+785.01 | Road x-ing | | | | | | | | | | | |
| 37+785.01 | 38+395.38 | 610.37 | 0.0000 | 0.578 | 1.733 | 1.90 | 0.91 | 1.30 | 0.465 | 3.724 | 0.00030 | 0 | 0.018 |
| | 38+395.38 | Thresher x-ing with Check to serve Labugaon Main Canal | | | | | | | | | | | |

## Link Canal 2 and 3

| LINK CANAL 2 & 3 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DISTANCE | Q | V | A | b | d | D | R | P | s | ss | n |
| FROM | TO | | $m^3$/sec | m/s | $m^2$ | m | m | m | m | m | | (H:1) | |
| 0+000.00 | 0+300.00 | 300.00 | 0.0000 | 1.834 | 10.654 | 4.60 | 2.32 | 3.25 | 1.154 | 9.232 | 0.00090 | 0 | 0.018 |
| 0+300.00 | 0+900.00 | Closed Conduit | | | | | | | | | | | |
| 0+900.00 | 1+000.00 | 100.00 | 0.0000 | 1.834 | 10.654 | 4.60 | 2.32 | 3.25 | 1.154 | 9.232 | 0.00090 | 0 | 0.018 |
| | 1+000.00 | Comb. Thr. X-ing , Check & Headgate of Lateral 1 | | | | | | | | | | | |
| 1+000.00 | 1+658.00 | 658.00 | 0.0000 | 1.828 | 10.549 | 4.60 | 2.29 | 3.20 | 1.148 | 9.187 | 0.00090 | 0 | 0.018 |
| | 1+658.00 | Comb. Road x-ing with Check Drop and T.O. # 2 L/S | | | | | | | | | | | |
| 1+658.00 | 1+800.00 | 142.00 | 0.0000 | 1.826 | 10.528 | 4.60 | 2.29 | 3.20 | 1.147 | 9.177 | 0.00090 | 0 | 0.018 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1+800.00 | Inlet of Chute Structure | | | | | | | | | | | |
| 1+800.00 | 2+400.00 | 600.00 | 0.0000 | 5.709 | 3.368 | 2.60 | 1.30 | 1.80 | 0.649 | 5.191 | 0.01880 | 0 | 0.018 |
| | 2+400.00 | Outlet ofChute Structure | | | | | | | | | | | |
| 2+400.00 | 3+470.00 | 870.00 | 0.0000 | 1.826 | 10.528 | 4.60 | 2.29 | 3.20 | 1.147 | 9.177 | 0.00090 | 0 | 0.018 |
| | 3+470.00 | Road x-ing | | | | | | | | | | | |
| 3+470.00 | 3+495.00 | 25.00 | 0.0000 | 1.826 | 10.528 | 4.60 | 2.29 | 3.20 | 1.147 | 9.177 | 0.00090 | 0 | 0.018 |
| | 3+495.00 | Road x-ing | | | | | | | | | | | |
| 3+495.00 | 3+941.00 | 446.00 | 0.0000 | 1.826 | 10.528 | 4.60 | 2.29 | 3.20 | 1.147 | 9.177 | 0.00090 | 0 | 0.018 |
| | 3+941.00 | Comb. Road x-ing , Check & Headgate of Lateral 2 | | | | | | | | | | | |
| 3+941.00 | 5+238.00 | 1297.00 | 0.0000 | 1.816 | 10.343 | 4.60 | 2.25 | 3.15 | 1.137 | 9.097 | 0.00090 | 0 | 0.018 |
| | 5+238.00 | Road x-ing | | | | | | | | | | | |
| 5+238.00 | 6+089.00 | 851.00 | 0.0000 | 1.816 | 10.343 | 4.60 | 2.25 | 3.15 | 1.137 | 9.097 | 0.00090 | 0 | 0.018 |
| | 6+089.00 | Road x-ing | | | | | | | | | | | |
| 6+089.00 | 6+426.00 | 337.00 | 0.0000 | 1.816 | 10.343 | 4.60 | 2.25 | 3.15 | 1.137 | 9.097 | 0.00090 | 0 | 0.018 |
| | 6+426.00 | Road x-ing with Check & T.O. # 5 L/S | | | | | | | | | | | |
| 6+426.00 | 6+500.00 | 74.00 | 0.0000 | 1.814 | 10.317 | 4.60 | 2.24 | 3.15 | 1.136 | 9.085 | 0.00090 | 0 | 0.018 |
| | 6+500.00 | Road x-ing | | | | | | | | | | | |
| 6+500.00 | 6+850.00 | 350.00 | 0.0000 | 1.814 | 10.317 | 4.60 | 2.24 | 3.15 | 1.136 | 9.085 | 0.00090 | 0 | 0.018 |
| | 6+850.00 | Comb. Road x-ing , Check , T.O. # 6 L/S & Headgate of Lateral 3 | | | | | | | | | | | |
| 6+850.00 | 7+350.00 | 500.00 | 0.0000 | 1.806 | 10.184 | 4.60 | 2.21 | 3.10 | 1.128 | 9.028 | 0.00090 | 0 | 0.018 |
| | 7+350.00 | Check Structure with T.O. # 7 L/S | | | | | | | | | | | |
| 7+350.00 | 7+700.00 | 350.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 7+700.00 | Inlet of Chute Structure | | | | | | | | | | | |
| 7+700.00 | 8+400.00 | 700.00 | 0.0000 | 6.132 | 2.995 | 2.40 | 1.25 | 1.75 | 0.612 | 4.896 | 0.02346 | 0 | 0.018 |
| | 8+400.00 | Outlet ofChute Structure | | | | | | | | | | | |
| 8+400.00 | 8+500.00 | 100.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 8+500.00 | Thresher x-ing with Check & T.O. # 8 L/S & T.O. # 9 R/S | | | | | | | | | | | |
| 8+500.00 | 10+100.00 | 1600.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 10+100.00 | Thresher x-ing with Drop | | | | | | | | | | | |
| 10+100.00 | 10+500.00 | 400.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 10+500.00 | Inlet of Chute Structure | | | | | | | | | | | |
| 10+500.00 | 11+200.00 | 700.00 | 0.0000 | 5.777 | 3.179 | 2.50 | 1.27 | 1.80 | 0.630 | 5.043 | 0.02001 | 0 | 0.018 |
| | 11+200.00 | Outlet ofChute Structure | | | | | | | | | | | |
| 11+200.00 | 11+300.00 | 100.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 11+300.00 | Thresher x-ing with Inclined Drop | | | | | | | | | | | |
| 11+300.00 | 11+600.00 | 300.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 11+600.00 | Inclined Drop | | | | | | | | | | | |
| 11+600.00 | 12+100.00 | 500.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 12+100.00 | Inclined Drop | | | | | | | | | | | |
| 12+100.00 | 12+860.00 | 760.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 12+860.00 | Inlet of Elevated Flume | | | | | | | | | | | |
| 12+860.00 | 13+014.00 | 154.00 | 0.0000 | 2.413 | 7.611 | 3.90 | 1.95 | 2.70 | 0.975 | 7.803 | 0.00195 | 0 | 0.018 |
| | 13+014.00 | Outlet of Elevated Flume | | | | | | | | | | | |
| 13+014.00 | 14+200.00 | 1186.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 14+200.00 | Inlet of Elevated Flume | | | | | | | | | | | |
| 14+200.00 | 14+319.00 | 119.00 | 0.0000 | 2.656 | 6.913 | 3.70 | 1.87 | 2.60 | 0.930 | 7.437 | 0.00252 | 0 | 0.018 |
| | 14+319.00 | Outlet Elevated Flume | | | | | | | | | | | |
| 14+319.00 | 14+500.00 | 181.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 14+500.00 | Thresher x-ing with Check Drop & T.O. # 10 L/S | | | | | | | | | | | |
| 14+500.00 | 14+900.00 | 400.00 | 0.0000 | 1.806 | 10.171 | 4.50 | 2.26 | 3.15 | 1.128 | 9.020 | 0.00090 | 0 | 0.018 |
| | 14+900.00 | Check Drop with T.O. # 11 L/S & T.O. # 12 R/S | | | | | | | | | | | |
| 14+900.00 | 15+910.00 | 1010.00 | 0.0000 | 1.800 | 10.078 | 4.50 | 2.24 | 3.15 | 1.122 | 8.979 | 0.00090 | 0 | 0.018 |
| | 15+910.00 | Road x-ing with Drop | | | | | | | | | | | |
| 15+910.00 | 16+100.00 | 190.00 | 0.0000 | 1.800 | 10.078 | 4.50 | 2.24 | 3.15 | 1.122 | 8.979 | 0.00090 | 0 | 0.018 |
| | 16+100.00 | Inclined Drop with Check and T.O. # 13 R/S & T.O. # 14 L/S | | | | | | | | | | | |
| 16+100.00 | 16+800.00 | 700.00 | 0.0000 | 1.798 | 10.051 | 4.50 | 2.23 | 3.10 | 1.121 | 8.967 | 0.00090 | 0 | 0.018 |
| | 16+800.00 | Inclined Drop | | | | | | | | | | | |
| 16+800.00 | 17+600.00 | 800.00 | 0.0000 | 1.798 | 10.051 | 4.50 | 2.23 | 3.10 | 1.121 | 8.967 | 0.00090 | 0 | 0.018 |
| | 17+600.00 | Thresher x-ing | | | | | | | | | | | |
| 17+600.00 | 18+500.00 | 900.00 | 0.0000 | 1.798 | 10.051 | 4.50 | 2.23 | 3.10 | 1.121 | 8.967 | 0.00090 | 0 | 0.018 |
| | 18+500.00 | Comb. Thresher x-ing with Check and Headgate of Main Canal 1 | | | | | | | | | | | |
| 18+500.00 | 18+530.00 | 30.00 | 0.0000 | 1.641 | 7.640 | 3.90 | 1.96 | 2.75 | 0.977 | 7.818 | 0.00090 | 0 | 0.018 |
| | 18+530.00 | Inlet of Elevated Flume | | | | | | | | | | | |
| 18+530.00 | 18+670.00 | 140.00 | 0.0000 | 2.271 | 5.522 | 3.30 | 1.67 | 2.35 | 0.831 | 6.646 | 0.00214 | 0 | 0.018 |
| | 18+670.00 | Outlet of Elevated Flume | | | | | | | | | | | |
| 18+670.00 | 19+850.00 | 1180.00 | 0.0000 | 1.641 | 7.640 | 3.90 | 1.96 | 2.75 | 0.977 | 7.818 | 0.00090 | 0 | 0.018 |
| | 19+850.00 | Thresher x-ing | | | | | | | | | | | |
| 19+850.00 | 21+033.00 | 1183.00 | 0.0000 | 1.641 | 7.640 | 3.90 | 1.96 | 2.75 | 0.977 | 7.818 | 0.00090 | 0 | 0.018 |
| | 21+033.00 | Road x-ing | | | | | | | | | | | |
| 21+033.00 | 21+220.00 | 187.00 | 0.0000 | 1.641 | 7.640 | 3.90 | 1.96 | 2.75 | 0.977 | 7.818 | 0.00090 | 0 | 0.018 |
| | 21+220.00 | Road x-ing | | | | | | | | | | | |
| 21+220.00 | 21+601.00 | 381.00 | 0.0000 | 1.641 | 7.640 | 3.90 | 1.96 | 2.75 | 0.977 | 7.818 | 0.00090 | 0 | 0.018 |
| | 21+601.00 | Comb. Road x-ing , Check , T.O. # 15 L/S & Headgate of Main Canal 2 | | | | | | | | | | | |
| 21+601.00 | 21+970.00 | 369.00 | 0.0000 | 1.566 | 6.642 | 3.60 | 1.84 | 2.60 | 0.911 | 7.290 | 0.00090 | 0 | 0.018 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 21+970.00 | Comb. Road x-ing , Check and Headgate of Main Canal 3 | | | | | | | | | | | |
| 21+970.00 | 22+772.00 | 802.00 | 0.0000 | 1.543 | 6.351 | 3.60 | 1.76 | 2.50 | 0.891 | 7.128 | 0.00090 | 0 | 0.018 |
| | 22+772.00 | Road x-ing | | | | | | | | | | | |
| 22+772.00 | 23+162.00 | 390.00 | 0.0000 | 1.543 | 6.351 | 3.60 | 1.76 | 2.50 | 0.891 | 7.128 | 0.00090 | 0 | 0.018 |
| | 23+162.00 | Road x-ing | | | | | | | | | | | |
| 23+162.00 | 23+433.00 | 271.00 | 0.0000 | 1.543 | 6.351 | 3.60 | 1.76 | 2.50 | 0.891 | 7.128 | 0.00090 | 0 | 0.018 |
| | 23+433.00 | Road x-ing with Drop | | | | | | | | | | | |
| 23+433.00 | 23+587.00 | 154.00 | 0.0000 | 1.543 | 6.351 | 3.60 | 1.76 | 2.50 | 0.891 | 7.128 | 0.00090 | 0 | 0.018 |
| | 23+587.00 | Road x-ing with Drop | | | | | | | | | | | |
| 23+587.00 | 24+045.00 | 458.00 | 0.0000 | 1.543 | 6.351 | 3.60 | 1.76 | 2.50 | 0.891 | 7.128 | 0.00090 | 0 | 0.018 |
| | 24+045.00 | Comb. Road x-ing , Check Drop , T.O. # 16 L/S & Headgate of Main Canal 4 | | | | | | | | | | | |
| 24+045.00 | 24+80000 | 755.00 | 0.0000 | 1.526 | 6.135 | 3.50 | 1.75 | 2.45 | 0.876 | 7.006 | 0.00090 | 0 | 0.018 |
| | 24+800.00 | Comb. Thresher x-ing , Check Drop & Headgate of Main Canal 5 | | | | | | | | | | | |
| 24+800.00 | 24+872.00 | 72.00 | 0.0000 | 1.516 | 6.024 | 3.50 | 1.72 | 2.45 | 0.868 | 6.942 | 0.00090 | 0 | 0.018 |
| | 24+872.00 | Comb. Thresher x-ing , Check & Headgate of Main Canal 6 | | | | | | | | | | | |

### *1.5.3.2.Related Canal Structures*

Various kinds of related new canal structure are tabulated in Table 9.

Table 9: Canal Structures
Link Canal 1

| no. | Station | | Type of Structures |
|---|---|---|---|
| 1 | 0+000.00 | | Intake of Link Canal 1 |
| 2 | 0+410.00 | | Steel Foot Bridge (w=1.00 m. - Existing) |
| 3 | 0+460.00 | | Drainage Culvert |
| 4 | 0+571.80 | | Spillway L/S - Existing |
| 5 | 0+577.30 | 0+740.00 | Closed Conduit (1-1.60 m. x 1.40 m. - Existing) |
| 6 | 0+830.00 | | Slab Foot Bridge (w=2.50 m. - Existing) |
| 7 | 0+900.00 | | Turnout # 1 L/S |
| 8 | 0+930.00 | 1+075.00 | Closed Conduit (1-1.60 m. x 1.40 m. - Existing) |
| 9 | 1+140.00 | | Comb. Road crossing, Check & Headgate of N.E. Lateral |
| 10 | 1+285.00 | | Road crossing - |
| 11 | 1+340.00 | | Drainage Culvert - Existing |
| 12 | 1+500.00 | | Turnout # 2 R/S |
| 13 | 1+600.00 | | Road crossing - |
| 14 | 1+700.00 | | Turnout # 3 L/S |
| 15 | 2+270.00 | | Check Structure with Turnout # 4 L/S & Turnout # 5 R/S |
| 16 | 2+650.00 | | Turnout # 6 L/S |
| 17 | 2+940.00 | | Check Structure with Turnout # 7 L/S |
| 18 | 3+048.00 | | Drainage Culvert |
| 19 | 3+430.00 | | Road crossing |
| 20 | 3+480.00 | | Drainage Culvert |
| 21 | 3+650.00 | | Turnout # 8 L/S & Turnout # 9 R/S |
| 22 | 4+000.00 | | Turnout # 10 L/S |
| 23 | 4+300.00 | | Turnout # 11 L/S |
| 24 | 4+550.00 | | Drainage Culvert |
| 25 | 4+743.00 | | Road crossing with |
| 26 | 5+188.00 | | Road crossing |
| 27 | 5+330.00 | | Turnout # 12 L/S & Turnout # 13 R/S |
| 28 | 5+435.00 | | Turnout # 14 L/S |
| 29 | 5+632.00 | | Road crossing with |
| 30 | 5+750.00 | | Turnout # 15 L/S |

| no. | Station | | Type of Structures |
|---|---|---|---|
| 31 | 6+000.00 | | Check Structure with Turnout # 16 L/S |
| 32 | 6+200.00 | | Drainage Culvert |
| 33 | 6+785.00 | | Drainage Culvert |
| 34 | 7+352.00 | | Drainage Culvert |
| 35 | 7+700.00 | | Road crossing |
| 36 | 7+856.00 | | Drainage Culvert |
| 37 | 8+300.00 | | Inclined Drop |
| 38 | 8+656.54 | | Road crossing with |
| 39 | 9+056.28 | | Drainage Culvert |
| 40 | 10+085.4 | | Existing Canal crossing |
| 41 | 10+385.2 | | Road crossing |
| 42 | 10+697.2 | | Road crossing |
| 43 | 10+968.9 | | Road crossing |
| 44 | 11+192.2 | | Road crossing with Check & Turnout # 17 L/S to serve Papa Left Main Canal |
| 45 | 11+197.7 | | Papa Left Main Canal crossing |
| 46 | 11+395.6 | 11+576.7 | Siphon with Road crossing at Inlet Transition |
| 47 | 12+129.5 | | Check Structure with Turnout # 18 L/S to serve Papa Right Main Canal |
| 48 | 12+139.5 | | Papa Right Main Canal crossing |
| 49 | 12+443.5 | | Road crossing |
| 50 | 12+481.6 | | Road crossing |
| 51 | 12+955.0 | | Road crossing |
| 52 | 12+967.4 | | Existing Canal crossing |
| 53 | 13+379.8 | | Road crossing |
| 54 | 13+416.0 | | Drainage Culvert |
| 55 | 13+785.1 | | Road crossing |
| 56 | 13+970.0 | | Drainage Culvert |
| 57 | 14+541.1 | | Road crossing |
| 58 | 15+089.4 | | Road crossing |
| 59 | 15+838.0 | | Existing Canal crossing |
| 60 | 15+850.0 | | Road crossing |
| 61 | 16+082.0 | | Drainage Culvert |
| 62 | 16+257.8 | | Road crossing |
| 63 | 16+450.0 | | Drainage Culvert |
| 64 | 17+350.0 | | Drainage Culvert |
| 65 | 17+675.0 | | Existing Canal crossing |
| 66 | 17+868.9 | | Road crossing |
| 67 | 18+359.8 | | Check Structure with Turnout # 19 L/S to serve Madongan Left Main Canal |
| 68 | 18+379.8 | | Madongan Left Main Canal |
| 69 | 18+983.4 | 19+375.0 | Siphon |
| 70 | 19+625.0 | | Madongan Right Main Canal crossing |
| 71 | 19+635.9 | | Road crossing with Check & Turnout # 20 L/S to serve Madongan Right |
| 72 | 19+663.2 | | Existing Canal crossing |
| 73 | 19+672.1 | | Road crossing |
| 74 | 20+059.9 | | Road crossing |
| 75 | 20+068.4 | | Existing Canal crossing |
| 76 | 20+528.0 | | Drainage Culvert |
| 77 | 24+612.0 | | Road crossing |
| 78 | 25+383.5 | | Drainage Culvert |
| 79 | 26+291.0 | | Drainage Culvert |
| 80 | 27+935.7 | | Drainage Culvert |
| 81 | 28+500.0 | | Drainage Culvert |
| 82 | 29+210.0 | | Drainage Culvert |
| 83 | 30+336.0 | | Drainage Culvert |
| 84 | 30+548.3 | | Existing Canal crossing |
| 85 | 30+702.2 | | Existing Canal crossing |
| 86 | 30+773.2 | | Existing Canal crossing |
| 87 | 32+515.6 | | Drainage Culvert |
| 88 | 34+178.1 | | Drainage Culvert |
| 89 | 34+888.5 | | Road crossing |

| no. | Station | | T y p e o f S t r u c t u r e s |
|---|---|---|---|
| 90 | 35+013.3 | | Existing Canal crossing |
| 91 | 35+046.7 | | Solsona Left Main Canal crossing |
| 92 | 35+056.7 | | Check Structure with Turnout # 21 L/S to serve Solsona Left Main Canal |
| 93 | 35+465.0 | 35+719.0 | Siphon with Road crossing at Inlet & Outlet Transition |
| 94 | 35+731.9 | | Solsona Right Main Canal |
| 95 | 35+741.9 | | Check Structure with Turnout # 22 L/S to serve Solsona Right Main Canal |
| 96 | 35+848.4 | | Existing Canal crossing |
| 97 | 36+000.0 | | Road crossing |
| 98 | 36+078.8 | | Existing Canal crossing |
| 99 | 36+171.5 | | Existing Canal crossing |
| 10 | 36+464.1 | | Road crossing |
| 10 | 37+000.0 | | Road crossing |
| 10 | 37+225.0 | | Existing Canal crossing |
| 10 | 37+443.3 | | Road crossing |
| 10 | 37+785.0 | | Road crossing |
| 10 | 37+818.4 | | Existing Canal crossing |
| 10 | 37+832.3 | | Existing Canal crossing |
| 10 | 38+395.3 | | Thresher crossing with Check to serve Labugaon Main |

Link Canal 2 and 3

| no. | Station | | T y p e o f S t r u c t u r e s |
|---|---|---|---|
| 1 | 0+000.00 | | Intake of Link Canal 2 & 3 |
| 2 | 0+300.00 | 0+900.00 | Closed Conduit |
| 3 | 0+975.00 | | Turnout # 1 L/S |
| 4 | 1+000.00 | | Combined Thresher crossing, Check and Headgate of Lateral 1 |
| 5 | 1+658.00 | | Combined Road crossing with Check Drop and Turnout # 2 L/S |
| 6 | 1+800.00 | 2+400.00 | Chute Structure |
| 7 | 2+950.00 | | Turnout # 3 L/S |
| 8 | 3+040.00 | | Drainage Culvert |
| 9 | 3+470.00 | | Road crossing |
| 10 | 3+495.00 | | Road crossing |
| 11 | 3+941.00 | | Combined Road crossing, Check and Headgate of Lateral 2 |
| 12 | 5+100.00 | | Turnout # 4 L/S |
| 13 | 5+238.00 | | Road crossing |
| 14 | 6+089.00 | | Road crossing |
| 15 | 6+426.00 | | Road crossing with Check and Turnout # 5 L/S |
| 16 | 6+850.00 | | Combined Thresher crossing, Check , Turnout # 6 L/S and Headgate of |
| | | | Lateral 3 |
| 17 | 7+350.00 | | Check Structure with Turnout # 7 L/S |
| 18 | 7+700.00 | 8+400.00 | Chute Structure |
| 19 | 8+500.00 | | Thresher crossing with Check and Turnout #8 L/S & Turnout # 9 |
| 20 | 10+100.00 | | Thresher crossing with Drop |
| 21 | 10+500.00 | 11+200.0 | Chute Structure |
| 22 | 11+300.00 | | Thresher crossing with Inclined Drop |
| 23 | 11+600.00 | | Inclined Drop |
| 24 | 12+100.00 | | Inclined Drop |
| 25 | 12+860.00 | 13+014.0 | Elevated Flume |
| 26 | 14+200.00 | 14+319.0 | Elevated Flume |
| 27 | 14+500.00 | | Thresher crossing with Check Drop and Turnout # 10 L/S |
| 28 | 14+900.00 | | Check Drop with Turnout # 11 L/S & Turnout # 12 R/S |
| 29 | 15+910.00 | | Road crossing with Drop |

| no. | Station | | Type of Structures |
|---|---|---|---|
| 30 | 15+934.00 | | Drainage Culvert |
| 31 | 16+100.00 | | Inclined Drop with Check and Turnout #13 R/S & Turnout # 14 L/S |
| 32 | 16+800.00 | | Inclined Drop |
| 33 | 17+476.00 | | Drainage Culvert |
| 34 | 17+600.00 | | Thresher crossing |
| 35 | 18+500.00 | | Combined Thresher crossing with Check and Headgate of Main Canal 1 |
| 36 | 18+530.00 | 18+670.0 | Elevated Flume with Slab Bridge @ Sta. 18+650.00 |
| 37 | 19+850.00 | | Thresher crossing |
| 38 | 20+420.00 | | Drainage Culvert |
| 39 | 21+033.00 | | Road crossing |
| 40 | 21+220.00 | | Road crossing |
| 41 | 21+601.00 | | Combined Road crossing, Check, Turnout # 15 R/S and Headgate of |
| | | | Canal 2 |
| 42 | 21+970.00 | | Combined Road crossing, Check and Headgate of Lateral |
| 43 | 22+772.00 | | Road crossing |
| 44 | 23+162.00 | | Road crossing |
| 45 | 23+433.00 | | Road crossing with Drop |
| 46 | 23+587.00 | | Road crossing with Drop |
| 47 | 24+045.00 | | Combined Road crossing, Check, Turnout # 16 L/S and Headgate of |
| | | | Canal 4 |
| 48 | 24+800.00 | | Combined Thresher crossing, Check and Headgate of Main Canal |
| 49 | 24+872.00 | | Combined Thresher crossing, Check and Headgate of Main Canal |
| | | | |

## 1.6 PROJECT PHASES AND TIMETABLE

Additional geological and geotechnical study is the recourse after an in-depth EGGA discovered, with the concurrence by NIA, that the proposed damsites are unsound. If this additional study could be started week-1 of Jan. 2020 and completed week-4 of Jul. 2020, then the SEIA can resume then completed maybe in week-4 of Dec. 2020.

Assumed no further respite, this shall be followed by a 2-year “preparation and detailed engineering design period” (week-1 Jan. 2021-week-4 Dec. 2022). Then this shall be followed by a 6-year “project construction period” with a 1-year preliminary (procurement) period—hence, shall cover week-1 Jan. 2023 to week-4 Dec. 2029).

The 1st 5 years of the subsequent system operations phase (week-1 Jan. 2030-week-4 Dec. 2034) shall be earmarked for the advocated Agricultural Development Stage (ADS) to shore-up project success. During the ADS, NIA shall spearhead program convergence of all the agri-supporting institutions into the service area to tackle existing and emergent production constraints.

The improvement in cropping intensity and crop yield shall have been achieved starting week-1 Jan. 2035, as the cut-in year for agricultural development.

## 1.7 SCREENING OF ENVIRONMENTAL ASPECTS, IMPACTS, AND RISKS

The screening of environmental aspects, impacts, and risks is used for focusing, levelling, and endpoints of the more relevant information for the EIS. This is also used in the listing of the stakeholders for public participation.

During pre-construction, no physical activity will be done; IEC activities and dialogues with the community will be done instead. Another activity during the pre-construction phase is the acquisition of ROW.

The main concerns during the construction phase is the possible accidents, noise, and emissions from vehicles brought about by project vehicles and equipment passing through barangays. Construction of new roads will require land clearing, excavation, and concreting, which will cause vegetation removal, increase in noise, excessive dust emissions during dry periods, and excessive soil erosion during rainy periods with increase in the total suspended solids in nearby bodies of water. Other risks include damage to poorly constructed road segments, as well as spillage of fuel and oil at the equipment staging or maintenance area. Clearing, earth excavation, and equipment staging works will also be done at the dam sites. This may result in increased soil erosion.

Another major component of the Project is the construction of proposed lined canals. This would also require clearing, earth excavation, and equipment staging works which may result to increase in soil erosion.

The main environmental aspect during the operation phase of the Project is the increase in fertilizer and agro-chemical use brought about by the year-round availability of irrigation waters. Increased use of these chemicals may have adverse effects on groundwater quality. The main environmental risk is dam failure, which will cause flood wave—that could result in damages and casualties.

Table 10: Environmental Considerations

| PROJECT ACTIVITIES | LAND | WATER | AIR | PEOPLE | MEASURES |
|---|---|---|---|---|---|
| **1.** ROW acquisition **for proposed access roads, irrigation canals, staging area, base camp, spoil disposal site** | Possible change in land use | | | Loss of property, Income in the proposed project areas Possible displacement of local residents | |
| **2.** Land use permit/authority **acquisition for the dumpsite, irrigation canals, staging area, basecamp, spoil disposal site** | | | | | |
| **3.** Construction of dam, irrigation canals, and support facilities | | | | | |
| **3.1. Land clearing for construction** | Loss of vegetation | Increase in TSS and | Insignificant and | | Collection of cut wood for |

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| **of proposed dam and support facilities** | Disturbance to wildlife<br>Loss of topsoil<br>Increase in soil erosion potential | browning of nearby bodies of water especially during wet season | localized increase in criteria air pollutants and noise from the operation of heavy equipment | | use<br>Replacement planting |
| **3.2. Excavations in and along the proposed dam and support facilities** | Loss of vegetation<br>Disturbance to wildlife<br>Loss of topsoil<br>Increase in soil erosion potential | Increase in TSS and browning of nearby bodies of water especially during wet season | Intermittent, sudden, and localized increase in TSP during dry season<br><br>Insignificant and localized increase in criteria air pollutants and noise from the operation of heavy equipment | | Designation of spoil disposal area<br>Immediate hauling of excavated materials to designated spoil disposal area |
| **3.3. Disposal of excavated materials to spoil disposal area** | Localized change in slope and topography<br><br>Increase in soil erosion potential | Increase in TSS and browning of nearby bodies of water especially during wet season | Intermittent, sudden, and localized increase in TSP during dry season | | Install erosion control measures in disposal area |
| **3.4. Stockpiling of construction concreting materials (gravel and sand)** | Increase in soil erosion potential | Increase in TSS and browning of nearby bodies of water especially during wet season | Intermittent, sudden, and localized increase in TSP during dry season | | |
| **3.5. Filling of rock materials at dam site** | Increase in soil erosion potential<br><br>Reduction of land area | Increase in TSS of nearby bodies of water | Intermittent, sudden, and localized increase in TSP during dry season | | Use of cofferdam |

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| | for wildlife<br><br>Submersion of trees | Increase in water level of river upstream of dam site | | | |
| **3.6. Concreting of dam** | Reduction of land area for wildlife | Intermittent water coloration | | | |
| **4. Operations of construction support facilities** | | | | | |
| **4.1. Use of unpaved access roads** | Increase in littered soil along paved road during wet season | Increase in TSS and browning of nearby bodies of water especially during wet season | Intermittent, sudden, and localized increase in TSP during dry season<br><br>Intermittent and localized increase in noise levels | Intermittent reduction in traffic flow<br><br>Risk of road accident | Provision of tire wash area<br><br>Use of water spray during dry season<br><br>Implementation of traffic safety plan |
| **4.2. Use of generator sets in project sites** | | | Localized increase in criteria pollutants and noise | | |
| **4.3. On-site refueling of vehicles** | Risk of fuel spillage | Risk of fuel spillage | | | Compliance with RA 6969 |
| **4.4. On-site maintenance of heavy equipment** | Risk of oil spill<br><br>Increase in the local solid waste | Risk of oil spill | | | Compliance with RA 6969 and RA 9275 |
| **4.5. Use of basecamp** | Increase in the local solid waste | Insignificant increase of human sewage loading into nearby bodies of water | | | Compliance with RA 6969 and RA 9275 |
| **5. Demobilization works** | Increase in solid waste | | | Risk of road accidents | Compliance with RA 9003<br><br>Implementation |

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| | | | | | of traffic safety plan |
| **6. Operations** | | | | | |
| **6.1. Maintenance of dam reservoir water level** | Decrease in the land area for wildlife<br><br>Localized migration of wildlife<br><br>Opportunity for local tourism (e.g. educational tours) | Opportunity for fisheries industry<br><br>Increase in fish population | | Opportunity for additional income from fishery projects and local tourism | |
| **6.2. Supply of water to irrigation networks** | Increase in the frequency of land for agricultural production<br><br>Change in ecology during dry season | Competition in water use<br><br>Increase in loading of fertilizers and pesticides | | Increased income for locals | |
| **6.3. Dam site office use** | Increase in the local solid waste | Insignificant increase in human sewage loading into nearby bodies of water | | | |