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LAND RECLAMATION STRATEGY FOR THE KEENLEYSIDE POWERPLANT PROJECT: CREATING OPPORTUNITY LANDSCAPES

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ABSTRACT

The Keenleyside Powerplant project requires an estimated 1.9 million cubic meters of material to be excavated over a 6 year period to facilitate the development of a powerhouse and intake structures adjacent to the Keenleyside dam near Castlegar. The excavated material is to be used for both construction purposes and for spoil. A 65 hectare area on the north bank of the Arrow Reservoir, upstream of the Keenleyside dam, has been designated as the spoil site. Much of this area was used for the original construction of the dam in 1972, and was never reclaimed.

A progressive, staged reclamation strategy is proposed by B.C. Hydro that identifies opportunity landscapes for recreation and wildlife enhancement along the Arrow reservoir. The spoil material from the powerhouse excavation is sequenced with nine potential areas in which new landscapes can be created. Proposed landscapes include wetland habitat with nature trails, a day-use recreation area, and a beach area.

The challenge of the reclamation strategy is to coordinate the removal of materials from the construction site, such that material suitable for construction needs is stockpiled nearby, and spoil material is hauled to designated sites for reclamation. Since the reclaimed sites have specific requirements for soils, the spoil must be sequenced with the specifications of each new landscape. The reclamation strategy is divided into 4 major stages over the construction period that outline the timing of the materials and volumes available for spoil placement.

A GIS is used as a data base to model the movement of materials and produce a digital terrain model (DTM) of the desired landscapes. The DTM will also be used as a tool for public input into the project to create final landscape designs for the spoil material.

INTRODUCTION

The Keenleyside dam is located upstream on the Columbia River approximately 10 kilometers from Castlegar. The site presently does not have generating capacity, and a powerplant is proposed by B.C. Hydro adjacent to the present dam. In order to construct the powerplant and associated intake structures, an estimated 1.9 million cubic meters of material will be excavated over a 6 year period. The excavation is complex, involving the removal of silts, gravels, boulders and a mixed variety of materials that could be used for construction purposes or disposed of as spoil. The horizons are interbedded fluvial and lacustrine deposits that require sorting as the excavation proceeds.

In most cases, where excavation involves large volumes, the suitable material for construction is stockpiled for use, and the remaining material is spoiled at a deposition site with minimal landscape enhancement. For example, the initial spoil disposal studies for the Keenleyside project identified a single dump site to deposit the spoiled material in a nearby gully. The deposition of spoil was viewed as a necessary evil.

This land reclamation strategy takes an opposite tact, and views the excavation of the spoiled material as an opportunity rather than an inconvenience. An area on the north bank of the Arrow reservoir, upstream of the Keenleyside dam has been designated for the spoil material. This area is approximately 65 hectares and was used for the original construction of the dam. The opportunity lies in the creation of new landscapes for recreation and wildlife habitat along the Arrow reservoir. Much of the foreshore area above the reservoir was disturbed as a result of the construction of the Keenleyside dam 20 years ago. The availability of spoil material from the powerhouse excavation provides an opportunity to reclaim the foreshore area for local residents and wildlife habitat.

This paper will provide an overview of the reclamation methodology applied to systematically deploy spoil to specific areas near the dam site for the creation of designed landscapes. The methodology used here employs 2 components: a Materials Balance Study and the formulation of potential landforms, termed "Opportunity Landscapes". The challenge of the reclamation strategy is to coordinate the removal of materials from the site to serve the purposes of both construction requirements, and the staged reclamation needs for the creation of new landscapes.

MATERIALS BALANCE STUDY

The Materials Balance Study provides a schedule for material excavated from the site, where soils may be used for construction or spoil purposes. The materials balance study determines:

1) the quantity and character of the material to be removed from the excavation site,
2) the timing of spoil removal, and
3) alternative sites for the storage or disposal of soils.

The primary reason for the Materials Balance Study is to match spoil material with disposal sites to create opportunity landscapes that will enhance the social and environmental quality of the area. The study coordinates the placement of 1.9 million cubic meters of spoil over a 6 year period.

Spoil Material Timing and Volumes

The construction phases of the project are the determining factor for the stages of spoil removal. These phases can be generalized as: the removal and relocation of the highway adjacent to the dam, construction of coffer dams, excavation of the powerhouse site, and coffer dam removal and channel completion. Each of the construction phases involves the excavation of large volumes of material for site needs and for spoil. To simplify the classification of materials for this purpose, the spoil was divided into 5 generic types based on size and construction needs (see Table 1).

Table 1
Spoil Material Types and Usage

MATERIAL	CHARACTERISTICS AND RECLAMATION USES
Sand and Silt	Fine materials, good for fill away from waterbodies and for topdressing.
Sand and Gravel	Fine and coarse materials, good for fill near waterbodies and for areas that require good drainage.
Till	Coarse materials in clay, used as a water barrier such as in the construction of wetlands.
Riprap	Large rock, used for berms, dams and erosion control.
Wasterock	Mixed rock, used for berms and erosion control.

The spoil material is to be excavated at different intervals over the 6 year construction period. The volumes are separated into 4 general stages over the construction period that coincide with the major construction activities previously described. Table 2 outlines the stages of excavation and the available material from each stage as the project proceeds.

Table 2
Spoil Material Timing and Volumes

MATERIAL	STAGE 1 (10months)	STAGE 2 (12months)	STAGE 3 (9 months)	STAGE 4 (5 months)	TOTALS
Sand and Gravel	376,860 (50%)	223,960 (30%)	0	154,980 (20%)	756,800
Sand and Silt	330,165 (46%)	293,480 (41%)	8,360 (1%)	85,800 (12%)	717,805
Till	0	49,940 (77%)	0	18,150 (23%)	68,090
Riprap	0	10,660 (20%)	0	41,145 (80%)	51,805
Wasterock	0	297,700 (92%)	0	25,870 (8%)	323,570
TOTAL					1,918,070

Spoil Area Description

There are 9 designated spoil areas located near the dam site. These areas were disturbed during the original construction of the dam in 1971, and cover approximately 65 hectares. Figure 1 outlines the location of different areas according to number. The areas vary in capacity from 100,000 to 700,000 cubic meters for holding spoil. These volumes are based on a variety of landscape requirements such as filling depressions (Areas 7, 11, and 12); or smoothing out rough surfaces (Areas 3, 4, 5, 6, 16, and 17); and creating larger features such as promontories (Areas 16 and 17). The potential fill volume within the 65 hectares is over 2 million cubic meters, providing flexibility for the creation of landscapes and disposing of the spoil volumes. Table 3 outlines spoil areas as designated in Figure 1, and describes the preferred materials for landscape construction, present and final uses, and available volumes for spoil disposal.

Much of the designated area for spoil is not presently used. However, there are some uses presently occurring within the 65 hectares. .Area 17 is frequently used by residents as a beach and camping area. Area 7 is a bay adjacent to the reservoir used for log sorting during highwater. Area 14 is fenced and used as a storage site by dam personnel, with a warehouse in the middle of the property.

OPPORTUNITY LANDSCAPES

The land reclamation strategy for this project is comprised of three parts:
Phase 1 - Opportunity Landscapes
Phase 2 - Public Involvement
Phase 3 - Final Landscape Design
Each of these phases is an integral part to the final landscape that will result at the completion of the project. The concept of an opportunity landscape provides the first step in a decision making process that integrates public values into landscape changes that better fit community uses and the creation of wildlife habitat (McLellan and Baker, 1994). Often, large projects such as hydro-electric development or mining are perceived as incompatible land uses by the community and media. In some cases, this image has been well deserved. However, an interest-based approach for developing a project will integrate community needs and yield substantial benefits to that community. Creative landscape changes can provide benefits to a project that aid in overcoming perceived incompatibilities for land use.

The Opportunity Landscape phase outlines design opportunities resulting from the Materials Balance Study. Once the sites are identified for the placement of spoil, and the timing of spoil materials is known, the remaining task is to construct landscapes that are compatible with the area.

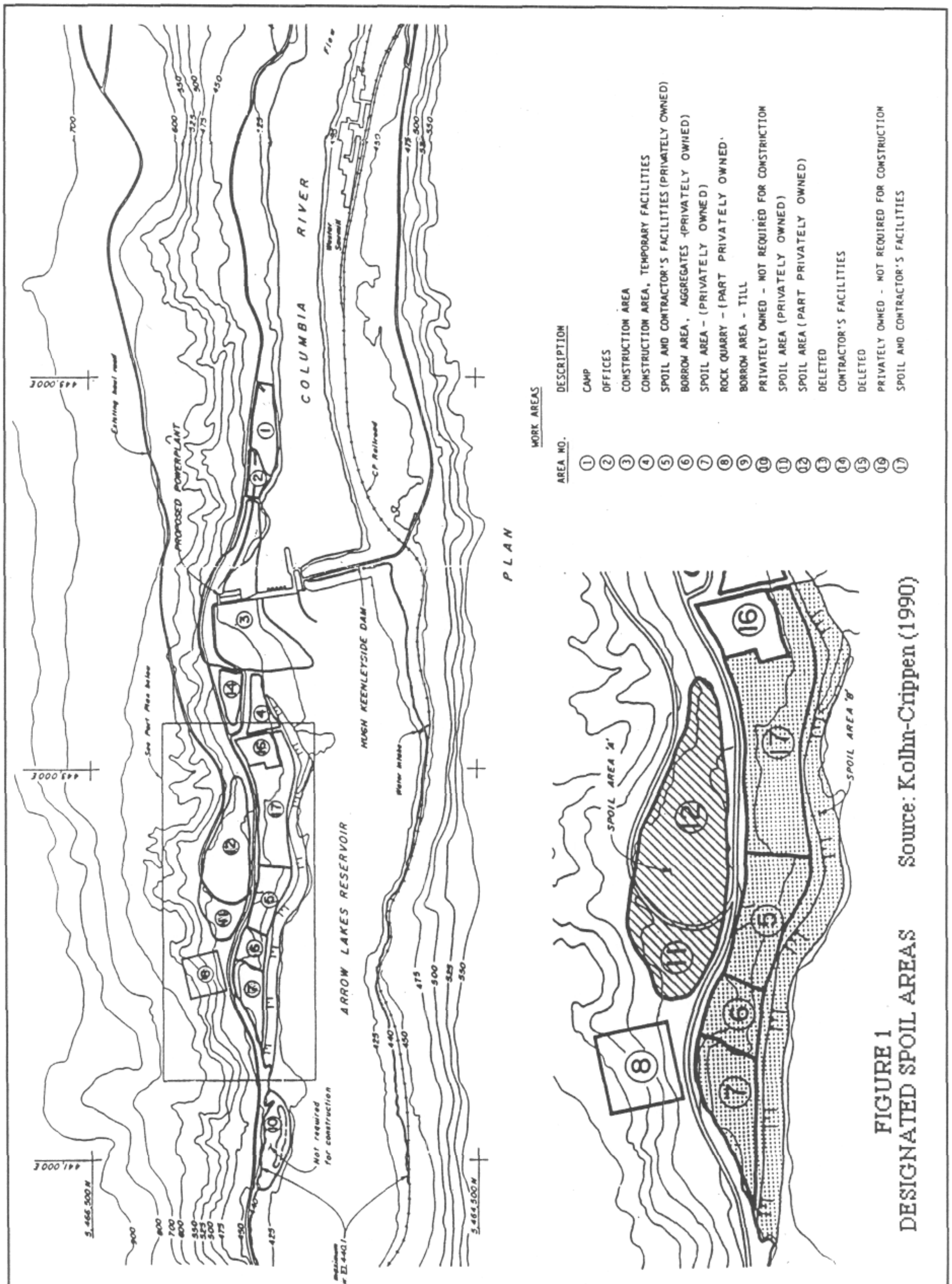


FIGURE 1
DESIGNATED SPOIL AREAS Source: Kolhn-Crippen (1990)

Table 3
Spoil Areas and Their Characteristics

SPOIL AREA	AREA (~ ha)	VOLUME (m3)	PRESENT USE	PREFERRED MATERIALS	FINAL USE
3 and 4 - Till Blanket	14	145,000	Grassed Steep Slope grading into till blanket.	Sand and gravel.	Till Blanket.
5 - Work and Spoil Area	4	130,000	Undulating area with some steep slopes.	Sand and gravel.	Recreation Area: Dayuse, camping or walking trails.
6 - Aggregate Source and Spoil Area	4	100,000	Undulating area with some steep slopes.	Sand and gravel; Tills for wetland proposal.	Recreation Area: Dayuse, walking trails or wetland habitat.
7 - Spoil Area	4	565,000	Bay-like feature that is largely underwater and used for log sorting.	Sand and gravel; Tills for wetland proposal.	Recreation Area: Wetland habitat or walking trails.
11 - Spoil Area	4	165,000	Small depression with rough slopes, holds water and has good native revegetation.	Sand and silts.	Maintain for wetland habitat or fill to grassed area.
12 - Spoil Area	12	400,000	Large depression with steep slopes, has small drainage system and good native revegetation.	Sand and silts.	Wildlife habitat or dayuse area.
14 - Work and Spoil Area	3	135,000	Small depression with some steep slopes; used for storage yard.	Sand and silts.	Storage Area.
16 - Spoil Area	10	700,000	Undisturbed plateau with steep slopes and promitory that reaches into the reservoir.	Sand and gravel; wasterock and riprap.	Recreation Area: Entrance to area, walking trails and lookout.
17 - Spoil and Work Area	10	110,000	Undulating area. Driftwood Beach area used for fishing and camping.	Sand and gravel; wasterock and riprap.	Recreation Area: Driftwood beach area with dayuse facilities.

The objective is then to approximate these landscapes with a model and solicit public input (Phase 2), to arrive at a finalized landscape design (Phase 3). This paper focuses only on the first phase of the reclamation strategy.

Definition of Areas and Preferred Materials

Areas 3 and 4 are to be maintained as a till blanket, as part of the dam design, and are not to be incorporated for a public use area. The materials for fill specified in this area are placed for erosion control and aesthetic concerns. Sand and gravel are the preferred material within this area.

Areas 5, 16, and 17 provide the main recreation area with a dayuse site, beach, walking trails and 2 promontories. The beach and the majority of the promontories should be constructed with sand and gravels. This reduces the concern of sedimentation into the reservoir and still provides suitable materials for a beach and walking trails. Some sands and silts may be used to topdress areas that are to be revegetated. Wasterock will also be used for the construction of the promontories as they reach into the reservoir, and the outside perimeter is to be lined with riprap for erosion control.

Areas 6 and 7 are appropriate areas for wetland habitat enhancement. This requires the placement of sand and gravels over till materials to produce a perched watertable and some modifications of the drainage system to increase flows to this area.

Areas 11 and 12 are large, borrow areas remaining from the initial construction of the dam that have not been reclaimed. Presently Area 12 is being used as an intermittent refuse dump (illegally). Both areas are away from the reservoir and would be most suitable for the spoil of fine sands and silts. These areas could be capped or layered with coarser sands and gravels to increase stability and control erosion. There is presently a small creek that flows through Area 12. This is not a natural course, but one created with the construction of the access road above the dam site. If Area 12 is to be filled, this creek will have to be redirected, possibly towards Areas 6 and 7 to supplement the proposed wetland habitat.

Area 14 is a small borrow area presently used as a storage facility. It would also be suitable for sand and silt spoil. This area has a defined and compatible land use with the dam site and may best be left as is.

Spoil Material Placement by Stages

Each of the described areas requires specific materials from the project excavation site. The spoil material to placed for each landscape is available according to the 4 stages of the project as defined in Table 2. The landscapes will not be complete until all 4 stages of the project are finished, with several stages often required to complete different land forms (for example, Area 6). The sequences are illustrated in Table 4.

Table 4
Spoil Material Placement

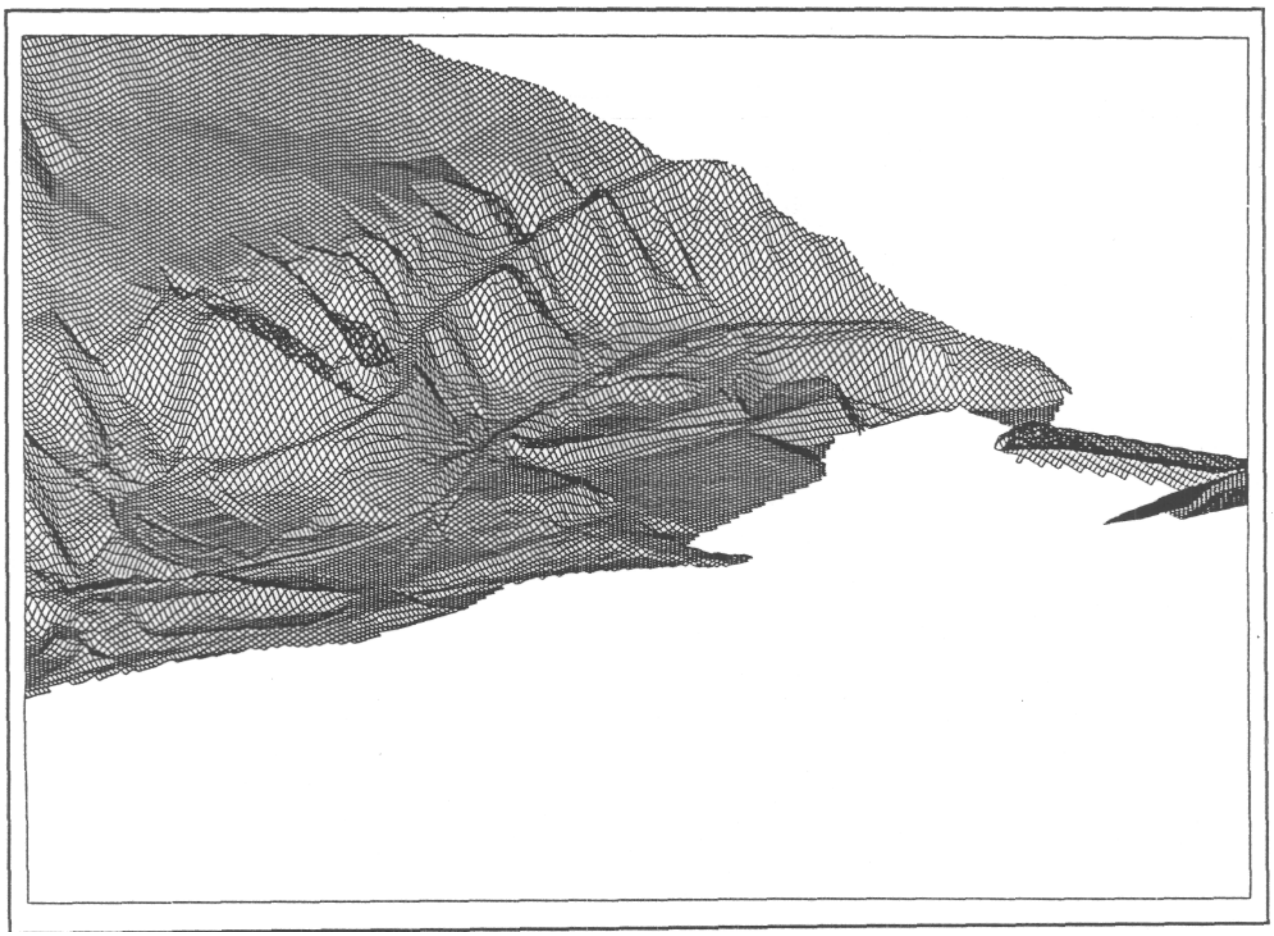
STAGE and MATERIAL	SPOIL VOLUMES	DESIGNATED AREA
STAGE 1		
Sand and Gravel	100,000 m3	Area 5
	121,000 m3	Area 7
	70,000 m3	Area 12
	85,000 m3	Area 17
Silt and Sand	330,165 m3	Area 12
STAGE 2		
Sand and Gravel	223,960 m3	Area 6
Sand and Silt	103,480 m3	Areas 3&4
	30,000 m3	Area 5
	135,000 m3	Area 14
	25,000 m3	Area 17
Till	49,940 m3	Area 6
Riprap	10,660 m3	Area 16
Wasterock	297,700 m3	Area 16
STAGE 3		
Sand and Silt	8,360 m3	Areas 3&4
STAGE 4		
Sand and Gravel	33,160 m3	Areas 3&4
	30,000 m3	Area 6
	91,820 m3	Area 16
Sand and Silt	85,800 m3	Area 16
Till	18,150 m3	Area 6
Riprap	41,145 m3	Area 16
Wasterock	25,870 m3	Area 16

With the different landscapes formulated according to staged spoil requirements, the Opportunity Landscape phase offers a rough guide for a more detailed and designed landscape. The final tool applied to this phase is the use of a Digital Terrain Model to model the different landscape characteristics for each area.

Digital Terrain Model

The Digital Terrain Model (DTM) is used for several purposes: to model fill volumes and land surface changes; to provide different perspectives of each area; and as a tool for the public input phase of the project (Phase 2). The DTM provides a three-dimensional data base for the larger area around the dam, and can be used to focus on single areas for finer landscape detail. Figure 2 provides a perspective of the reclamation site from the south-west, across Arrow reservoir.

Figure 2
Digital Terrain Model of Reclamation Site



Further application of the DTM will be used for detailed assessments of individual landscape areas. Volumes and surface changes can be modelled at larger scales to provide a basis for more detailed site designs that might incorporate features such as specific types of vegetation, park buildings, or routes for walkways. The DTM supplies a consistent data base for any changes to the proposed landscapes, and provides detailed contour maps of the entire area.

CONCLUSION

The reclamation methodology developed in this paper consists of 2 components: a Materials Balance Study, and the formulation of Opportunity Landscapes. The Materials Balance Study coordinates the placement of soils as they are excavated from the powerhouse site. The excavated material is either stockpiled for construction use, or spoiled. As the project proceeds, the periods of excavation are linked to potential spoil disposal sites according to soil type and available volumes. Opportunity Landscapes outline the design opportunities resulting from the materials balance study. Once the available volumes and the timing is known, approximate designs need to be formulated to construct compatible landscapes for the area. This involves identifying potential sites that can be feasibly used and examining the physiographic constraints. The Opportunity Landscape phase is the first phase in formulating a finalized design. The remaining phases consist of public involvement for local input into the design (Phase 2), and the finalized detailed design completed at a large scale, site level (Phase 3). The success of large scale reclamation strategies depends on integrating each of these components to meet the needs of the project and the local community.

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