Rainfall in the City of Rio de Janeiro.

Although the rainfall in the City of Rio de Janeiro, which is situated on the Atlantic Coast, is not directly applicable to connection with the rainfall in the interior on the head waters of the São Francisco (though they are on the western bank of the same latitude) it is very near, and indeed, as varying more or less analogous irregular fluctuations, largely induced by causes operating at a remote distance from both regions.

Through the kindness of Dr. Joaquim dos Santos, Civil Engineer, I have had access to printed records of the rainfall and evaporation kept at the Observatory in the City of Rio de Janeiro; the rainfall from 1851 to 1867, seventeen years, and the evaporation from 1858 to 1867, ten years. Before O. A. Dutry obtained records of the rainfall in this City from 1782 to 1787, eleven years; and from 1788 to 1792, thirteen years. These are all 51 years of records.

The Observatory is in the City, on the Castello Hill, 62.7 meters (202.66 feet) above the sea, in latitude 22° 57' 12" South, and longitude 43° 08' W. from Greenwich. The record, during the 17 years, was kept by Antonio Francisco Correia de Araujo.

A table is appended, showing the rainfall for each month, and the evaporation in each month, for ten years.

The average yearly rainfall for 17 years, from 1851 to 1867, included, was 1117.2 millimeters.
The greatest yearly rainfall, in 1862, was 1536 mm.
The least, in 1855, was 829 mm.
The maximum yearly rainfall (1862) was 1832.24 mm, the minimum in 1855 689.85 mm.
To the 10 years, from 1858 to 1867, the average yearly rainfall was 1152 millimetres.

During the same 10 years, the average yearly evaporation was 1647 mm. The evaporation being 43 mm. cent. greater than the rainfall.

The average monthly evaporation was greater than the average monthly rainfall in all the months except March; although in the years 1861, 64, 65 and 66, the evaporation in March was greater than the rainfall.

In the exceptional year 1862, in the month of March the rainfall was 400 millimetres, while the evaporation was only 80 mm.

The average annual rainfall of 1112 millimetres was exceeded during the years 1853, 57, 58, 59, 61, 62, 65; while it fell below during the years 1851, 52, 54, 55, 56, 60, 63, 64, 66 and 67.

The highest monthly rainfall was in December, 149.3

The lowest was in June, 48.5

The greatest rainfall in any month of the 17 years was in May, 1853, 408 millimetres, and nearly the same in March, 1862, 400.85 mm.

The least was in August, 1866.

(1852 and 1853, it was very dry.)

For convenience reform the following results are tabulated from the records:

<table>
<thead>
<tr>
<th>Monthly average rainfall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>119</td>
</tr>
<tr>
<td>February</td>
<td>92</td>
</tr>
<tr>
<td>March</td>
<td>143</td>
</tr>
<tr>
<td>April</td>
<td>106</td>
</tr>
<tr>
<td>May</td>
<td>10.8</td>
</tr>
<tr>
<td>June</td>
<td>43.50</td>
</tr>
<tr>
<td>July</td>
<td>42</td>
</tr>
<tr>
<td>August</td>
<td>69.50</td>
</tr>
<tr>
<td>September</td>
<td>57.50</td>
</tr>
<tr>
<td>October</td>
<td>99.50</td>
</tr>
<tr>
<td>November</td>
<td>149</td>
</tr>
</tbody>
</table>
### Average yearly rainfall for 17 years.

<table>
<thead>
<tr>
<th>Year</th>
<th>Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1851</td>
<td>988</td>
</tr>
<tr>
<td>1852</td>
<td>532</td>
</tr>
<tr>
<td>1853</td>
<td>1391.3</td>
</tr>
<tr>
<td>1854</td>
<td>1012.5</td>
</tr>
<tr>
<td>1855</td>
<td>821</td>
</tr>
<tr>
<td>1856</td>
<td>1000.4</td>
</tr>
<tr>
<td>1857</td>
<td>1203</td>
</tr>
<tr>
<td>1858</td>
<td>1181.25</td>
</tr>
<tr>
<td>1859</td>
<td>1027.62</td>
</tr>
<tr>
<td>1860</td>
<td>1236.17</td>
</tr>
<tr>
<td>1861</td>
<td>1536.23</td>
</tr>
<tr>
<td>1862</td>
<td>964.49</td>
</tr>
<tr>
<td>1863</td>
<td>1256.36</td>
</tr>
<tr>
<td>1864</td>
<td>781.67</td>
</tr>
<tr>
<td>1865</td>
<td>1098.73</td>
</tr>
</tbody>
</table>

Average 1112 for 17 years.

From some additional records, the rainfall was as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1782</td>
<td>1272</td>
</tr>
<tr>
<td>1783</td>
<td>1673</td>
</tr>
<tr>
<td>1784</td>
<td>1306</td>
</tr>
<tr>
<td>1785</td>
<td>1407</td>
</tr>
<tr>
<td>1786</td>
<td>1367</td>
</tr>
</tbody>
</table>

Average for 6 years: 1263.

<table>
<thead>
<tr>
<th>Year</th>
<th>Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1868</td>
<td>978</td>
</tr>
<tr>
<td>1869</td>
<td>525</td>
</tr>
<tr>
<td>1870</td>
<td>824</td>
</tr>
<tr>
<td>1871</td>
<td>1012</td>
</tr>
<tr>
<td>1872</td>
<td>1792</td>
</tr>
<tr>
<td>1873</td>
<td>810</td>
</tr>
<tr>
<td>1874</td>
<td>1324</td>
</tr>
</tbody>
</table>

Average for 8 years: 1099.

Summing the 17 years, 6 years, and 8 years, making in all 31 years, the average yearly rainfall would be 1138.

The fluctuations of the quantities of rain in different months, in different years, are very great, and quite irregular as the annexed table shews:

<table>
<thead>
<tr>
<th>Month</th>
<th>Rainfall</th>
<th>Year</th>
<th>Month</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>284.8</td>
<td>1862</td>
<td>Jan</td>
<td>38.8</td>
</tr>
<tr>
<td>Feb</td>
<td>198.72</td>
<td>1862</td>
<td>Feb</td>
<td>19.50</td>
</tr>
<tr>
<td>Mar</td>
<td>400.85</td>
<td>1862</td>
<td>Mar</td>
<td>38.8</td>
</tr>
<tr>
<td>Apr</td>
<td>268.40</td>
<td>1859</td>
<td>Apr</td>
<td>19.50</td>
</tr>
<tr>
<td>May</td>
<td>409.8</td>
<td>1859</td>
<td>May</td>
<td>14.2</td>
</tr>
<tr>
<td>Jun</td>
<td>129.52</td>
<td>1865</td>
<td>Jun</td>
<td>5.8</td>
</tr>
<tr>
<td>Jul</td>
<td>129.52</td>
<td>1865</td>
<td>Jul</td>
<td>4.8</td>
</tr>
<tr>
<td>Aug</td>
<td>286.00</td>
<td>1865</td>
<td>Aug</td>
<td>3.8</td>
</tr>
<tr>
<td>Sep</td>
<td>112.00</td>
<td>1860</td>
<td>Sep</td>
<td>15.0</td>
</tr>
<tr>
<td>Oct</td>
<td>160.29</td>
<td>1860</td>
<td>Oct</td>
<td>12.0</td>
</tr>
<tr>
<td>Nov</td>
<td>195.63</td>
<td>1860</td>
<td>Nov</td>
<td>11.7</td>
</tr>
<tr>
<td>Dec</td>
<td>233.70</td>
<td>1860</td>
<td>Dec</td>
<td>12.9</td>
</tr>
</tbody>
</table>

Year | 1862 | 1863 | 1864 | 1865 | 1866 | 1867 | 1868 | 1869 | 1870 | 1871 | 1872 | 1873 | 1874 | 1875 | 1876 | 1877 | 1878 | 1879 | 1880 | 1881 | 1882 | 1883 | 1884 |
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>36</td>
<td>19.50</td>
<td>38.8</td>
<td>19.50</td>
<td>14.2</td>
<td>5.8</td>
<td>4.8</td>
<td>3.8</td>
<td>15.0</td>
<td>12.0</td>
<td>11.7</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td>12.9</td>
<td></td>
</tr>
</tbody>
</table>

The average rainfall was: 1138.
While it is true that there was no month absolutely without rain, the minimum quantities in some months were quite insignificant. When it is considered that ten millimeters are only a little more than one third of an inch, it will readily be seen that such small quantities as 3, 4, or 5 millimeters in a month, are of little account.

In 1855 the rainfall in the four consecutive months of June, July, August, and September was only 10.1 mm, while in the same months in 1853 it was 37.4 mm. (1.48 inches)

Taking the six months in December, January, February, March, April, May, they fell in 1851-52, 1122 millimeters, and in 1857-58, 350 —

The greater being almost exactly double of the lesser.

During 6 of the other six months, namely, October, November, December, and January, the maximum in 1853 was 579 millimeters while the minimum, in 1851, was 243 —

The greater being 2.42 times the lesser.

The rainfall in August 1853 was 286 millimeters, while in 1854 it was only 7 mm.

In May 1853, it was 408 mm, while in May 1852 it was only 29 mm.

No regular periodicity can be traced in these records; although the wet and dry seasons are literally well defined: — the wet season from December 1st to May 31st, and the dry season from June 1st to November 30th, inclusive. There is, however, no rigid, unyielding line of demarcation; in some years the rainfall is greatly reduced during the wet season, and in some years it is much increased during the dry season.
Dr. Gay

Many years of personal experience on the slopes of the
Serra do Mar, about 60 kilometers back from
the city of Rio de Janeiro, showed similar circumstantial
one noticed rain; though it is not known that they
corresponded with the incalculantia at the city of Rio de Janeiro.

The evaporation in the City of Rio de Janeiro is, as
the records show, considerably greater than the rainfall.
The proportion of evaporation to rainfall is probably greater
throughout the valley of the São Francisco. It is certainly
so along the lower portion of the Upper river.

Dr. Gay, through the foregoing, we have been furnished
with the
accelerated statement of the rainfall at the observatory
on Castello hill from 1868 to 1879 inclusive. During these 12 years
the annual mean rainfall was 837.337, and taking the 29 years
from 1851 to 1879 inclusive, the annual mean rainfall was 998.30

<table>
<thead>
<tr>
<th>Years</th>
<th>Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1868</td>
<td>812.2</td>
</tr>
<tr>
<td>1869</td>
<td>404.1</td>
</tr>
<tr>
<td>1870</td>
<td>673.5</td>
</tr>
<tr>
<td>1871</td>
<td>755.5</td>
</tr>
<tr>
<td>1872</td>
<td>1149.7</td>
</tr>
<tr>
<td>1873</td>
<td>814.0</td>
</tr>
<tr>
<td>1874</td>
<td>1356.0</td>
</tr>
<tr>
<td>1875</td>
<td>1036.0</td>
</tr>
<tr>
<td>1876</td>
<td>1144.0</td>
</tr>
<tr>
<td>1877</td>
<td>641.7</td>
</tr>
<tr>
<td>1878</td>
<td>337.2</td>
</tr>
<tr>
<td>1879</td>
<td>863.6</td>
</tr>
</tbody>
</table>

Average 837.33 for 12 years
Rainfall in Ceará, etc.

Appended is a table of the rainfall at Fortaleza, the capital of the province of Ceará. It is situated on the Atlantic Coast in latitude 3° 42' 50' South, and longitude 38° 28' 38' West, and is 194 Kilometers from Fortaleza. The province of Ceará lies north of the great bend of the São Francisco Valley, separated from it by the Serra de Capibaribe. The distance from the São Francisco river to the Atlantic Ocean of this province does not exceed thirty-five leagues or about 194 Kilometers.

Large areas in the interior of Ceará have at irregular periods suffered from destructive Arreiros, continuing sometimes for several years. This region is only now beginning to recover from a terrible visitation of Arreiros which has continued for more than three years.

So far as I could learn no rain-gauge has been kept in the interior of the province, but from general information it is probable that the rainfall in the interior is more irregular and with greater fluctuation than it is along the Coast.

Senator Thomas Pompeu de Lima, published in 1877, a book entitled "Memória sobre o Clima e Secas de Ceará," in which a great number of tables relating to the rainfall at Fortaleza, and as they appear to be Confirmatory of the views naturally arising from a study of the other records, they are here added. They have been re-arranged so as to be easily studied in connection with the other records, and the data presented by the Senator have not been in the least changed.
This record gives the average monthly rainfall at Fortaleza in each month during the years 1849 to 1876 inclusive, a period of 28 consecutive years, as follows:

**Average during 28 years - Annual rain-fall.**

<table>
<thead>
<tr>
<th>Month</th>
<th>millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>69</td>
</tr>
<tr>
<td>February</td>
<td>797</td>
</tr>
<tr>
<td>March</td>
<td>287</td>
</tr>
<tr>
<td>April</td>
<td>372</td>
</tr>
<tr>
<td>May</td>
<td>274</td>
</tr>
<tr>
<td>June</td>
<td>238</td>
</tr>
<tr>
<td>July</td>
<td>45</td>
</tr>
<tr>
<td>August</td>
<td>14</td>
</tr>
<tr>
<td>September</td>
<td>11</td>
</tr>
<tr>
<td>October</td>
<td>13</td>
</tr>
<tr>
<td>November</td>
<td>83</td>
</tr>
<tr>
<td>December</td>
<td>36</td>
</tr>
</tbody>
</table>

Average yearly for 28 years: 1469

This table, by itself, would convey only an imperfect idea of the Meteorology, even at Fortaleza; and still more imperfect with regard to the Interior, where slight rains which would show in the rain-gauge, are evaporated almost as soon as they reach the ground, and do not...
Independently of abnormal periods of drought, there is an annual periodicity, clearly establishing a rainy season and a dry season. Thus the average annual rainfall during the first 6 months of the year, January to June inclusive, was 1346 millimetres, while for the other 6 months it was only 143 millimetres.

The greatest rainfall during the 1st 6 months was 2335 millimetres (in 1866).

The least rainfall during the 1st 6 months was 206 millimetres (in 1874).

The greatest yearly rainfall was in 1866, 2453 millimetres.

- 1872: 2290 millimetres
- 1873: 2042 millimetres
- 1849: 1907 millimetres

The least rainfall was in:

- 1867: 850 millimetres
- 1874: 855 millimetres
- 1853: 1005 millimetres
- 1850: 1022 millimetres

The greatest yearly rainfall, 2453 millimetres (in 1866), was 2.87 times the least rainfall, 850 millimetres (in 1867).

The minimum yearly rainfall was practically the same in 1874 (855 millimetres) as in 1867 (850 millimetres).

The greatest half-yearly rainfall during the first 6 months was as follows:

- 1866: 2335 millimetres
- 1872: 1929 millimetres
- 1873: 1902 millimetres
- 1849: 1760 millimetres

The least half-yearly rainfall during the second 6 months was in 1874:

- 1874: 80 millimetres
- 1872: 29 millimetres
- 1873: 53 millimetres
- 1849: 36 millimetres
- 1867: 42 millimetres
- 1863: 46 millimetres

Practically it may be considered that during these years there was no rain for 6 months.
The greatest rainfall during the 6 months of dry season was in 1871, 1885, which proved to be one third of that year's rainfall. (1489 millimeters)

The yearly rainfall was above the average during the years 1849, 52, 54, 56, 57, 60, 66, 69, 70, 72, 73, 75 and 76, thirteen years, and below the average during the years, 1850, 51, 53, 55, 58, 59, 61, 62, 63, 64, 65, 67, 68, 71, and 74, fifteen years.

An inspection of the table of rainfall, or the Curve made from it, will show only circularity, without the slightest semblance of periodicity. But of course a record of only twenty-eight years, considered by itself, may be inadequate to aid in the study of supposed long cycles of years.

The average rainfall at (near) Sabará, in the Province of Minas Gerais, at the head waters of the São Francisco River is 4 ft. The record was 1637 millimeters. At the City of Rio de Janeiro was 1112. At the City of Fortaleza, (Ceará) was 1289.

And in each of the regions where the records were kept, there is an annual period of a rainy season and a dry season, each predominating, approximately, through the same months of the year.

Fortaleza and Rio de Janeiro both Cowt Cities; Fortaleza being in latitude 3° 49' and Rio in 22° 49'.

The records show an average rainfall at Fortaleza 1.34 feet greater than the average at Rio de Janeiro.

Comparing the records of these two Cities, it will be found that their periods of Maximum and Minimal do not correspond. Only in five out of twenty-five years, from 1851 to 1875, do they nearly correspond, namely, in 1851, 55, 57, 63, 64, 67, 68, 71, and 72. In the other 15 years they do not correspond at all, and in some years, as for example in 1866, the Contrast is striking. That was the year of maximum rainfall at Fortaleza, while in Rio it was far below the average.
There was one year, 1872, in which there was a marked coincidence, that being the maximum in both cities, but in the succeeding year, 1873, the rainfall at Fortaleza was far above the mean, while in Rio it was far below; and the next year, 1874, it was very far below at Fortaleza, and far above at Rio. Regularly, there was no predominance in either city of maxima and minima and scarcely the semblance of any correspondence between the two places in the years greater and less rainfall. Neither was there anything similar.

If careful calculations were to be made and theories or hypotheses were to be based upon the rainfall records in one of these cities, they could be confirmed by the records in the other city.

It would require a long series of records kept in many years' summer months, to obtain data upon which correct theories could be founded; but the tables here considered are valuable, as far as they go; and they afford a tangible idea of the extent and periods of rainfall in their respective districts.

It is true that these tables are entirely insufficient to account for the occasional visitations of such disastrous droughts, as the one just ended, which embraced a large portion of Ceará, including Paracuru, Picunhy, Rio Grande do Norte, and Paraíba.

The minimum amount of rainfall at Fortaleza, namely, in 1869, was 853 millimeters, and almost precisely the same in 1874; but in 1875, and 1876, nearly equal to the quantity there. The maximum of 853 millimeters in 1873 is 2.80 feet, or 85.5 English inches, is quite sufficient in the tropical zone for agriculture; but is depends upon time, and when it falls, even there; and in the
Before it may be an important. But from the best authenticated information respecting the interior of Cedano no such quantities of rain fell as are exhibited in the records kept at the Capitol during the years 1877, 1878, 1879, as given in the pamphlet just published by Chief Engineer Morley, giving an Historical Synopsis of the

And it is by a found that in April of was no

It is certain very remarkably that throughout the present region during a period of 31 years there should be an average rainfall of 1489 millimeters (58 1/2 inches) during 28 years, and then suddenly

The importance of the subject is so great that no apology would seem to be needed for devoting a little time to its study. It is important in a scientific view; but vastly more important in an economic and humanitarian view than that

Institution formed by Moorhouse, Queen's, and Joseph

organized— not to change the Meteorological Code, or

of similar Nature.
Estima do Cot.

The following is an approximate estimate of the cost of the proposed improvement of the Upper São Francisco river.

From Pirapora Falls to the head of the Schradinhe rapids, 1028 kilometers ("clear river") — — — — 35,000,000

Informing one of the Cachoeiras, from the head of the Schradinhe rapids to Teresópolis, the upper terminus of the Paulo Affonso Railway, 458 kilometers. 1491: 520,000

Add 20 per cent. for Contingent, Superintendence, etc. 98: 320,000

Add one light draught steamer 90,000

One small light draught steamer 23,000

Allow interest on capital, etc. 40,000

Total. 144: 800,000

In round numbers seven hundred and fifty centavos.

If the work, as it could be, were required to be completed in two years, probably no more than fourth or one third would need to be expended the first year, while the chief would be devoted to the final examination, on the Cachoeiras, and the preparation of materials; and experienced might show it to be advisable to spend only a part of the revenue during the second year, improving the lower rapids.
I am disposed to call particular attention to the special report of Dr. Theodoso Fernandes de Sampaio, Civil Engineer, Member of this Commission, who, under instructions from the Chief Engineer, dated December 23, 1879, proceeded across the Country, from Camarunha, in the valley of the São Francisco to the City of Bahia, noting among his journey of about 150 leagues (825 kilometers), numerous interesting and important features of the extensive region traversed.

Dr. Sampaio's report is so clear, concise, and full of valuable information as to entitle it to the most careful study of every person who takes an interest in the general and particular characteristics, capabilities, past and present condition, and future prospects of an extensive area of the interior of Brazil; part of which is directly connected with the more immediate valley of the São Francisco River.

The report consists of four Chapters, followed by a statement referring to the excellent accompanying map of the Country between Camarunha and the City of Bahia.

Chapter I. Begins at Camarunha, in the left bank of the São Francisco River, 1643 kilometers from the mouth, and describes the region thence to Monte Alto, 15 leagues (83 kilometers).

Chapter II. Describes the Country between Monte Alto and the City of Caetité, a distance of 15 leagues (83 kilometers).

Chapter III. Describes the region from Caetité to the town of Rio de Contas, 22 leagues (122 kilometers) and 20 leagues (111 kilometers) beyond Rio de Contas to St. Isabella do Parmaguassii; together, 42 leagues (233 kilometers)
Chapter IV. Describes the region from 3rd. Sabu de Paraguay to S. Felix, opposite the town of Caxixe, about 65 leagues (361 kilometers). Thence to the city of Bahia, about 15 leagues (72 kilometers), no new description was necessary.

After studying this report, I understood to make a synopsis; but it became so voluminous as to almost a repetition of its already condensed matter; I will therefore give here only the "Statement" of S. Sampaio, explanatory of the "Accompanying Map," but respectfully suggesting that the full report, which will be found in the Appendix, deserve careful perusal.

"Statement Accompanying Map.

The Map which accompanies this report is the result of careful and conscientious efforts in gathering exact data and information for the organization of a better map of this part of the Province of Bahia than as present exists.

Of all the Empire this Province is the poorest as to geographical data and the knowledge of its territory. The four Companhias between the rivers "São Francisco," "Ivri," Paraguay and "Río Caritas" was indeed the most unknown and most imperfectly represented in the Maps hitherto published. It was on this account that we attempted to cross the region in this part.

For the purpose of obtaining a more perfect acquaintance with this region, we stayed a few days at the heads of the districts, Companhias, in our journey, and had the good fortune to gather a great amount of information, as to the river, their course, size, and principal affluents, and in regards to the forests, campo, lakes and marshes, villages, towns and cities of each Municipalities.
So that the map which accompanies this report, if it does not present the exactitude of geographical and graduated pro-
duction, has, nevertheless the advantage of being among
many, the nearest to correctness of any which I have be-
amenoned representing this part of the Province of Bahia.

Thus, I did not treat with a single map of this
province as to the town of Elantas-Alto figured in
its true position; this town has always been represented
at more than 20 leagues distance from the São Fran-
ce River, and beyond the valley of this river, when it is
well known to be only 15 leagues distant from the São Francisco,
and as many more to the West of the Serra Geral, the limit of
the valley referred to.

The same may be said as to the geographical
position of the City of Cactité and other growing towns
scattered on the very fertile table-lands of the Serra
Geral.

The sources of the Rans, St. Christoph and Para-
minim rivers, with other affluents of the São Francisco,
and their branches, are here more correct according
to trustworthy information, and more in harmony with the
class of the geographers of Brazil, Father Manuel Agost
de Casal, the most reliable in descriptions of the
places I traversed.

The source and Course of the Cova de and Para-
guassú rivers and their affluents, are in the same Case.

With regard to the Paraguassú, I have to note,
that no geographical Map of this zone is exact as to the
source and upper Course of this long river.

Upon this point, fortunately, with the aid of the
best information, and principally, with the testimony of
an Historico-Geographical Native of these Remote
districts which was furnished to me a short time
ago, by the near General of the Rio das Contas Company,
Canon José de Sousa Marques, I succeeded in making a Correção as reliable as was possible with such assistance.

The Serras or Mountain-Chains are on this map more clearly laid down, and more in accordance with nature than in other maps. The forests, the Caatingas, the Campos gerais, are also indicated here according to the data of our direct observations, and in accordance with good information from more than one individual consulted on the same subject.

Such are the improvements and correçãos that we have succeeded in introducing into the maps of this part of the Province of Bahia.

"Nicolau Fernandes de Sampaio
Ensigneiro Civil."

It may properly be added, that the above conveys only a faint idea of the extent and value of the information contained in the field reports, which relate not only to the geography, but to the topography, geology and climate, as well as to the mineral and agricultural characteristics of the different zones between that part of the immediate way of the São Francisco and the Atlantic Coast.
Concluding Suggestions.

Shoule the Government continue to improve the Upper São Francisco River upon the general plan described in this report, it may be a question for consideration respecting the manner of doing the work; whether by the government directly, or by Contract under government supervision. In the United States, whatever it may be practicable, such works are done by Contract, under government supervision.

In either case, if the government wishes to save time, it would be advisable to make arrangements for the construction and delivery on the Upper river of two iron-hulled, light-draught steam-boats; the larger to be about 240 meters long and 6 meters wide; for a tow-boat, the smaller to be not more than 15 meters long and 4 meters wide, for an exploring boat. Neither named, when light, should move more than half a meter.

Such boats could be Constructed, finished, and built in the United States, and delivered complete, in the Upper river (after the opening of the Paulo Offenso Railway) for not exceeding the sums Mentioned in the General Estimate of Cost. Namely, 90,000 for the larger, and 25,000 for the smaller boat. How much less than these sums can only be ascertained by special examination or through proposals.

Secondly, in case the government should endeavor to proceed at once with the improvement of the river, it would be an advantage to engage the services of some one who had had experience in planning.
and executing analogous river works. Although the
banks themselves are as simple as possible, money may be
saved by judicious selection of the particular places in
which it is, rip-rap rocks, or planks, are to be put. An
intelligent engineer unaccustomed with such work might
time acquire the necessary experience, but experience is
generally paid for by somebody.

In general, it is not feasible to designate, exactly, such
improvements as may, upon more careful investiga-
tion be found desirable. The smaller steamboat
referred to in this document, mainly, to be used in ma-
kings these preliminary critical investigations on the Cach-
neras; and in the hands of one experienced in
river-improvement, the examinations and decisions
could be made very rapidly.

The general method of making these final examina-
tions, during the low water season, seems to be to have an
experienced river-man in charge of the exploring
steamboat and, with a small party of intelligent as-
dants, to be selected by himself, to ascertain all the naviga-
table channels at every Cachnero, noting the features
(especially those to each Channel), depth, width, Current, Vel-
shq of Wadi, Obstruction, etc., before determining which
Channel should be improved, and how it should be improved.

These critical examinations cannot be properly made
without the use of a proper light-channel steamboat, as
indicated, having room enough to place the steamer, totally of the
natural Channels. Steamboat, or Steam-Canoe, Channeling a mite and a quarter to a mile and a half of
unite, an nor or any adapted to this purpose.

(With the aid of sail, the Commission was enabled
to sail up through some of the Channels and note
their features; but the land is too uncertain an element to depend upon, as it sometimes failed in where it needed it most. Besides, a general examination of the whole river, and also a critical examination of each Cape Cachoeira, on one season, and then been an impossibility.)

It would not be necessary for the Engineer in Charge of the examinations to wait until the Close of the season, or till after examining all of the Cachoeiras before reporting plans. That could be done by making beginning with the lowest, and then after the examinations Should be Completed at each of the Cachoeiras.

In a general way it is assumed that the low-water season would be consumed in making these preliminary investigations and arranging for the procurement and delivery, at Convenient points on the river Hero, of such Undertoned timber, and rough stone from quarries, as might be Considered necessary for the Improvement of certain Cachoeiras; and the succeeding low-water season the work should be done - if not at all, at the most Difficult Cachoeiras; so as to ensure a Considerably Improved navigation for the former low-water season.

It should not be part of the duty of the Engineer in Charge, to keep company or view merely the Improvement of the low-water navigation, (by means of the simple works indicated,) but to be sure that the Channel might also be safe in thicker stages of the river. This calls for the exercise of judgment based upon some experience in the action of rivers in their different stages.
It may be stated, that no river in the Union bears a closer resemblance to that portion of the São Francisco between Pataua and Sobradinho—the Cacheusus portion; and that therefore precisely similar works have not been required on any of those rivers, yet the same kind of judgment exercised in planning and improving the low-water navigation of the Ohio river is needed in the Upper São Francisco. Here is this very important difference between these two streams; that while the minimum flow of water on the Ohio, in some seasons, becomes very small, the minimum flow in the Upper São Francisco even in the very driest season is a large volume. The water in the upper portions of the low-water supply on the São Francisco, more than atones for the greater velocity of the stream through the Cacheusus; so that a better low-water navigation can be made on the São Francisco than on the Upper Ohio, without the use of locks.

The Labor of the Commission are now brought neatly to a close, and it gives me great pleasure to bear testimony to the uniform kindness and courtesy received in the matter; and to their cheerful and diligent fulfillment of the various duties assigned to them which has so essentially contributed to produce satisfactory results.

My association with these gentlemen in this Commission for more than a year, in the field, and in the office, has been most agreeable; the recollections of our intercourse will always be a source of sincere pleasure; and their future career as engineers, whenever they may be, will be regarded by me with especial interest.

Accompanying this is the report of Prof. H. O. Derby upon the geology of the São Francisco Valley.
Continuation of the population, and the circumstances in the San Francisco Valley, with the view of making an approximate estimate of the probable traffic after the rail shall have been improved, and the Lemoisson Railway opened.

Various estimates have been published of the population of this valley, that could be regarded as tributary to rail service, varying from a million and a half down to three hundred thousand.

It is difficult, or perhaps impracticable, to obtain exact reliable statistics; but the Commission has sought to ascertain the truth upon this point, partly from personal observation and judgment, and partly from such statistics as were attainable.

Four members making separate approximate estimates, each in his own way, placed between 450,000 and 580,000; the average being 516,000 inhabitants.

Then the best attainable statistical sources relating to the parishes in the river provinces of Minas Geraes, Bahia, Pernambuco, Alagoas and Sergipe, theremen states, 521,754, as the present number that may be considered tributary.

The number of houses could not be ascertained in all of the parishes, but in those which were obtained there were 70,622 houses to 461,830 people. In the same proportion for a population of 521,754, the total number of houses would be 74,834.

The average number of people to each house, according to the above statistics, is 6.4 and 6.7.
I appended to this report, exhibits in
detail the names of the provinces, their munici-
palities, and parishes, and the number of
houses and inhabitants in each.

Accuracy is not required for the purposes
of this report, so that the above number of
houses and inhabitants may be taken as a
corpuscular, near approximation as a general
case.

I appended also the names of the towns along the
river, triangles in the
respective provinces, to the number of forty-one
and their distances in kilometers below Porpor.

- The elevation of the river at each place above the
sea, and the number of the league upon which
they are situated, designating also in which
district of the river they stand. If there are the
names and distances of tributary rivers.

This table shows that the towns along the
river, where business must be conducted for trade,
average less than ten leagues apart.

The whole length of the upper and lower river,
which is 382 leagues— from the sea to the

Between the towns, wherever the land is
Cultivable, which includes perhaps three-fifths
of the length, it is Cultived, as already stated,
for the hopes, pastures, and some of the low grounds;
though toward the upper part of the valley there
are large tracts of low-lying land not yet
under cultivation.

To make an estimate of the value
of the future trade of the valley of the river,

Two things should be considered: First, the effect,
means of transportation.

of the improved upon the labor, habits and modes
of the present inhabitants and their natural increase.

In December, and second, the increase of

time are the consequences of such increase, in

augmenting production as well as the demand

for imported articles.

It is quite reasonable to infer that if there

had been a natural, practicable continuous nav-
gation from the sea to Piriporo, that the cir-
cumstances of the Valley, and of the people, both

in their present and their habits, would have

been essentially different from their present con-
dition. The Country in the interior would

have been far more advanced, and manu-

factures of various kinds would probably

have been long ago introduced at numerous

points.

An artificially improved navigation, in

connection with a stage road, around the

Paako oranges falls, while it is of course not
equally to an uninterrupted river, with a

very great improvement over the present chie-

fainst and obstructed stream; and as such it

is reasonable to infer that it would a time

exert a powerful and beneficial influence

upon the comfort and general welfare

of the whole valley.

Time is mentioned as an element,
because experience all over the world has
shown that peoples are slow to change

long-established manners and customs, new

when the strongest inducements are presented.

Nevertheless there are many of natural
energy and enterprising in some of the Commercial ports along the river, who will step forward and use their influence in encouraging such changes as will tend to increase General Trade.

Lacking at the Circumstances, it has seemed reasonable to assume, first as first, a weekly line of Steamers plying between Jatoba and Piracuara, and Chief, between Jatoba and Jamaná (which is 298 kilometers below Porto-Pará), each Steamboat taking two barges, will transport all the exports and imports that even offer for that particular mode of transportation.

If the Cargo each time, each way, should average 250 Tons, the Annual Imports would be 13,000 Tons, and annual exports 13,000. And if the number of Passengers, of all kinds, should average only 20 each time, each way, it would give 2,800 upward, and 2,800 downward, and amount.

According to experience elsewhere, the amount of tonnage and number of Passengers would turn by largely more than the above, but these amounts are independent of the traffic that might still go on for a few years under the present system of Carros and Canoes; and of course as we include the very much greater navigation business that the improved Navigation will be the means of developing in the future.

It is not in my power to specify amounts of future Trade and Traffic on this river, but
estimate of that kind must necessarily be largely
conjectural. The circumstances are here
fairly presented; and those who are most
familiar with the problem can judge what
is likely to be the result of opening such an
extensive valley, by comparatively easy Commu-
nication, to General Commerce.

In the estimated cost of improving the river,
there is an item of $40,000,000, for the first steamboat
of the class recommended to be used in the Upper
river. It is estimated that this first other similar
steamer could afterward be placed on the Upper
river at a cost of about $5,000,000 each, or $20,
cars for the four. The total cost of the 5 being ac-
cording to this estimate, $390,000,000.
The barge, to carry about 100 tons each, may
cost about $10,000,000 each; and it would require
at least twenty barges, perhaps thirty, to do the busi-
ness in cases where they would be essential. After the construction of such barges
would be undertaken along the coast, their cost might
be materially reduced. But for present calculations and
to be on the safe side, let it be assumed that the
first cost of thirty barges will be $300,000,000;
and that they will last ten years.
The life of a steamboat may also be assumed for
present calculations, at ten years; although numerous
steamboats are known to last much longer.
The first cost of 5 steamboats, say $390,000,000
$300,000,000
$690,000,000

Add 10% for Contingencies,
Supervision, etc., $69,000,000

Total first cost $759,000,000

Annual interest at 6% per ct. $43,708,000
Annual Expenses.

Interest, as above. 53130400
Repairs and renewal of buildings 5112
Cemmence Expenses

Intens as above 63,130,000
Repairs and renew of 5 steam boats 37,480,000

Running 5 steamers 1 year including officiers, hands, fuel, oil and all ordering running expenses at 34,000 each 170,000

Running 30 barges 1 year including Captain, 4 hands, and all ordering running expenses at 7,000 each 210,000

Running expenses 389,000

Add annual cost of general superintendence 40,000

Total annual cost 569,000

If we assume that 20,000 tons should be carried (each way) half the length of the improved road, or 877 kilometers, the result would be as follows:

569,910,000

40,000

141.75 per ton

The actual cost, if all be charged to freight,

Would be 141.75 per ton, for the distance of 877 kilometers.

This would be at the rate of 16.50 per ton, per

kilo- meter.

If double that rate, or 32.50 per ton, per kilometer, were charged, upon such assumed distance, carried 877 kilometers, it would of course afford a profit of 16

16.50 per ton per kilometer, and 569,910,000 a aggregate

profit. (Whatever may be changed, up to 16

per ton or the sum assumed) would be demands

additional profit. It is not intended by this framing
to recommend any particular rates of charge.)
Data censure of such regularity, to the extent of 40,000 tons yearly, must not be anticipated for some years. Certainly nothing of the kind could be relied upon in the beginning. The calculations seem known to show the final cost of transportation under such exceedingly favorable circumstances.

It is impossible to say, in advance, what the currents will be, either as to their extent or in character, during the first years after the establishment of good navigation. Parties who might be inclined to enter the steamboat and barge carrying trade on this river, should of course, make a special examination and careful study of all the circumstances, without relying solely upon preliminary estimates of any one.

In case there were 10,000 tons carried, an average distance of 877 kilometers, with 3 steamboats and 18 barges, calculating in a similar manner, the actual cost per ton for the whole distance of 877 kilometers would be 15.772, or 15 3/4 per ton per kilometer. Then would be 115.20 per annum for 877 kilometers.

The service, with 3 steamers instead of 5, assuming 12 trips per annum to each steamer between Jatoba and Pirapora, would be at intervals of 1/2 day instead of 7 days; perspective of the tonnage carrying. 3 steamers, 5 instead of 7 days; 24,000 tons are allowed in order to keep 4 steamers steadily running. No allowance of another steamer's made in the succeeding calculations at the same 3 steamers. In strictness, another steam

[Note: Page 7 is mentioned, possibly indicating continuation or reference at the bottom of the page.]
The first cost of 3 steamboats, say 180,000 & 000
1,800,000 & 000
1,800,000 & 000
4,05,000 & 000
Add 10 per cent. for Contingencies,
Superintendence, etc.
Total first cost above
Annual interest at 7 per cent.
Annual Expenses.

Interest, at above, for 1 year
31,185,100
Repair and renewal of 3 steamboats
19,980,000
Repairing 3 steamers 1 year, including
Officers, Hands, fuel, oil, and all
ordinary running expenses at
240,000 & 000
Running 15 barges 1 year including
Captain, 4 hands and all ordi-
nary expenses @ 7.500% each,
131,400 & 000
2,31,400 & 000
Estimated Total yearly cost 315,453 & 000

Carrying 10,000 tons Carried each way 877 Kilometers,
it would be
315,453 & 000
20,000 tons
= 15.772 per ton.

That would be the Actual Cost, if all were charged
upon the above freight. Doubly that rate, or 31.544
per ton, would throw a profit equal to the Actual
Cost, or 315,453 & 000 for 1 year.
This charge would be at the rate of 36 Reis per ton per
Kilometer. It would be 225 Reis per annum for the
Distance of 877 Kilometers.

18
Discussion of the Cost of Transportation, etc.

The peculiar circumstances of the São Francisco Valley render it rather difficult to produce a very satisfactory estimate of the present population contributory to the river trade, and its present amount. Various estimates have been made at different periods of the population. Engenheiro Krauss, in 1869, offered an approximate estimate making a probable population of 300,000, which seems to have been too little. Engenheiro Halffeld's estimate of 1,500,000, embracing all the Upper Valley, and including all real and potential settlers, seems to have been an over-estimate, except when referring it to river business. From the best information that the Commission could gather, it is considered to be about 520,000 in the immediate Valley of the São Francisco, with inhabitants and others likely to be regarded as contributory to the trade on the river.

Engenheiro Krauss's estimate of the probable amount of business in the beginning, after the completion of the improvements, was 600,000 arrebas, each way, equivalent to 1,200,000 arrebas one way. He estimated the yearly cost of transportation on the river by steamers of 140-200 horse power each, with 20 cargoes, as follows:

- Freight on cost of steamers (Cor. 400:000,000) 28:000:000
- 15% same capital, amortization 60:000:000
- Repossessions and Caducities 100:000:000
- Combustible, agüe, gasóis, etc. 90:000:000
- Tributação 42:000:000
- Agencias, Geraes e demais 320:000:000

Total 320:000:000
Estimada Cost of transporting 9,600 tons (2000 lbs.) per annum, 1/3 of the total distance, or 100 leagues.

For tonelada e legua 9,600 x 100 = 960,000,000 ripa.

550 ripa per ton = 5 v. 10 reis.

Dr. Krauss estimated the cost of transportation on the river at 11 reis per arroba per league, and by pack-animals by land from Joaçari to Petra, about 120 leagues, at 28,800.

And by pack animals from Vargem Redonda to Piranthar, at 900 reis per arroba.

And by river from Piranthar to Penedo, at 100 reis per arroba.

The estimated the cost between Joaçari and Petra by the proposed railway, at 18,920 per arroba; and 5.5 reis per arroba per league on the river, and 20 reis per arroba for transhipment at Joaçari.

He estimated the cost of the Paulo Affonso Railway as follows:

<table>
<thead>
<tr>
<th>Route</th>
<th>Cost (reis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penedo to Piranthar (river)</td>
<td>100 reis</td>
</tr>
<tr>
<td>Piranthar to Jatobá (railway)</td>
<td>350 reis</td>
</tr>
<tr>
<td>Shipments at Piranthar and Jatobá</td>
<td>40 reis</td>
</tr>
<tr>
<td>Cost in Navigation &amp; Upkeep to Joaçari</td>
<td>80 reis</td>
</tr>
<tr>
<td>Total</td>
<td>570 reis</td>
</tr>
</tbody>
</table>

Con mais 5.5 reis por legua da Navegação a vapor allo ndó.

The question of the future Cost of Transportation in the São Francisco Valley is one of importance, and amending the former investigation. To limit in its elucidation, the annexed Table, prepared by Dr. Krauss, Eugenio, in 1869, and Contained in his Report, is here quoted.
<table>
<thead>
<tr>
<th>Place</th>
<th>Distance</th>
<th>Feet</th>
<th>Metres</th>
<th>Kilometers</th>
<th>Fee</th>
<th>Piastres</th>
<th>Fee</th>
<th>Piastres</th>
<th>Fee</th>
<th>Piastres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rama do nio das Velhas</td>
<td>244</td>
<td>3,726</td>
<td>3,358</td>
<td>4,541</td>
<td>311</td>
<td>4,341</td>
<td>2,923</td>
<td>4,280</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ville 1 de S. Romão</td>
<td>217</td>
<td>4,987</td>
<td>3,014</td>
<td>2,86</td>
<td>4,146</td>
<td>2,143</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>de Jamana</td>
<td>190</td>
<td>4,490</td>
<td>2,915</td>
<td>2,59</td>
<td>3,849</td>
<td>1,995</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>de Carinhamba</td>
<td>160</td>
<td>4,000</td>
<td>2,700</td>
<td>2,29</td>
<td>3,579</td>
<td>1,830</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>do Urua</td>
<td>120</td>
<td>3,920</td>
<td>2,480</td>
<td>1,89</td>
<td>3,079</td>
<td>1,610</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>da Barrada Pingo</td>
<td>80</td>
<td>3,480</td>
<td>2,260</td>
<td>1,49</td>
<td>2,639</td>
<td>1,390</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>de Tique Tique</td>
<td>68</td>
<td>3,343</td>
<td>2,194</td>
<td>1,37</td>
<td>2,507</td>
<td>1,314</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>de Pilas Lencedo</td>
<td>50</td>
<td>3,150</td>
<td>2,095</td>
<td>1,19</td>
<td>2,309</td>
<td>1,225</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amaice de Rianonco</td>
<td>36</td>
<td>2,996</td>
<td>2,018</td>
<td>1,05</td>
<td>2,155</td>
<td>1,148</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ville 2 da Santa Be</td>
<td>18</td>
<td>2,798</td>
<td>1,919</td>
<td>87</td>
<td>1,957</td>
<td>1,049</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>de Jorgeiro</td>
<td>—</td>
<td>2,600</td>
<td>1,820</td>
<td>69</td>
<td>1,759</td>
<td>950</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>da Capim Gross</td>
<td>17</td>
<td>2,787</td>
<td>1,918</td>
<td>53</td>
<td>1,672</td>
<td>886</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>da Ita Vela</td>
<td>21</td>
<td>2,831</td>
<td>1,936</td>
<td>48</td>
<td>1,523</td>
<td>834</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>de Calombo</td>
<td>36</td>
<td>2,996</td>
<td>2,018</td>
<td>33</td>
<td>1,363</td>
<td>752</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estação Sato Bica</td>
<td>69</td>
<td>3,359</td>
<td>2,200</td>
<td>0</td>
<td>1,000</td>
<td>570</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This table of the probable cost of transportation may not show what the actual cost in practice may be, but it shows the relative cost, under the circumstances named, according to the judgment of an intelligent engineer independent of any reference to the capital employed in constructing the lines or works.
According to the Table, the cost of transportation of freight between Joaçari and Bahia by land conveyed on araba, in 1869, was $2,600 per ton, or per ton, 10.94 per cent.

And by the proposed railway between Joaçari and Bahia, 1890, per araba, or per ton, 11.37 per cent.

And between Joaçari and Penedo, by upper river to Vargem Redonda, pack-anandrolo to Piranhas, and lower river to Penedo,

1875, per araba, or per ton, 10.89 per cent.

And also by improved river from Joaçari to Jatobá, Jatobá by land to Piranhas, and Piranhas to Penedo by lower river.

900 per cent, or per ton, 9.85 per cent.

The table also gives the compared figures of freight cost from the Banda do Rio das Velhas to Bahia, and Penedo, respectively, as follows:

From Banda do Rio das Velhas to Bahia, in 1869, river

and the usual route over land between Joaçari and Bahia,

\( \approx 5\% \) 202 per araba, or per ton, 32.81 per cent.

From Banda do Rio das Velhas to Penedo,

in 1869, by upper river to Vargem Redonda, pack-anandrolo to Piranhas, and lower river to Penedo, 4\%421 per araba, or per ton, 24.6% 317.

Also, the

river, and proposed railway from Joaçari to Bahia, 3\%157 per araba, or per ton, 19.6% 937.

And by improved river, and proposed railway

between Jatobá and Piranhas,

2\%280 per araba, or per ton, 14.2% 500.
672,000 arbutas at $900 reis 638,400$ 000 638,400$ 000
And if the same amount be other way $1,376,800$ 000

Calling 4.5 per cent of this profit
$619,560$ 000

Dr. Kraun called the distance,
on river 69 leagues, in railway 39 leagues.
This amount of $619,560$ 000, after paying
the interest on original Capital $430,600$ 000) would,
show a net balance of $198,560$ 000

There was, however, another important Con-
consideration for the people of the San Francisco
Valley, relating to the two routes to the Coast,
which were thus compared.

According to the above showing from Dr
Kraun's Table, the inhabitants of the Upper San
Francisco Valley would be taxed annually upon
the conveyance of 672,000 arbutas, each way,
between the Valley, and the Coast, between
Napa and Patricia,
2,140,080$ 000
Or to, by River, to Jutaba, and
Pottage railway, to Portoauto,
and river to Peneau,
$1,376,800$ 000
$1,070,280$ 000

And with double of the above tonnage
1,344,000 arbutas each way the
annual difference would be doubled or $2,140,560$ 000

With greatly augmented daily Annual Traffic, the dif-
f erence would be proportionally greater, because the
Cost per arbuta, on the River, would diminish
more than it would on the Railway.
The foregoing and all other calculations can be no more than approximations, valuable when considering different methods proposed for the accommodation of the trade and travel of the São Francisco Valley.

At present the trade upon the Upper river consists chiefly of the purely local traffic between the towns located along the near margin, chiefly the exchange of food products, in quite limited quantities than usual among a like number of people elsewhere. The reason for this has been stated; chief among which is the isolation of this valley, and the general contentment of the population long accustomed to a humble way of living. Until this shall be changed the demand for imported articles must continue limited; and time is required to change the primitive agricultural methods to more modern systems. That advancement will immediately begin upon the opening of convenient and cheap transportation facilities then need to no doubt. Entering upon new land thus up the latent energies of the people, and arouse their ambition to equal others who live in more favored regions. Besides, there are populations at some distance from the river now having little or no communication. Thereafter, when it shall be opened to the Coast, as proposed, will be encouraged to raise products for shipment, which they cannot now afford to do.

It is therefore proper to look forward to a future large increase of Valley business, though it may be impracticable to bring such periods of time, or exact amounts of trade and travel.
Portage Actual Cost of Transportation, etc.

The actual cost of transportation, here, a, elsewhere, is controlled by the circumstances. If there is a regular supply, in large quantities, of readily-handled products, the minimum price may be charged; but if the supply is irregular, in small quantities, and the products, are troublesome to handle, the maximum price may be charged.

In the particular case of this river, where it shall be improved, one of the questions is whether the interest on the cost of improvement, it is, to be charged against the trade and traffic on the improved river. Assuming that the cost in terms of money is $50, 000, 000, the interest at 7 per cent. would be $3, 500, 000 per annum.

On 10, 000 ton, or 500, 000 arrobas, the unpaid amount to $3, 250 per ton, or 77 cts per arroba. On 20, 000 tons, or 1, 000, 000 arrobas, it would amount to $2, 625 per ton, or 38 1/4 cts per arroba.

And so, in proportion, for larger amounts of traffic, the charge per ton and per arroba would decrease.

In case the government should improve the river or the cost of the government, it will be optional with the government whether to charge, or not, the interest of the cost to the future river traffic.

In case private parties be authorized to do the work and maintain the improvement, it would be incumbent upon such parties to count the cost of the improvement, and its maintenance, as part of the capital upon which the traffic should be charged, the same as for the cost of steam costs, etc.
It is therefore obvious that the rate of charges for
transportation on the river will depend, to the ex-
tent just shown, upon the manner in which
the river shall be improved—whether by the gov-
ernment, or by authorized individuals at their
own cost.

It is not presumable that the government will
undertake to put up steamboats and conduct
transportation on the river, by government
employees, even in the event of their improvement
of the river; (except the furnishing of the two boats
mentioned in the estimate of first cost.)

If the government shall elect, and if a company
or an individual shall undertake to do the work
and furnish the necessary appliances and
means to maintain the improvement and conduct
the business on the river, there would be, of course, an
understanding between the government and such
company or individual, defining rates, proper to
be charged for transporting freight and passengers.

With regard to the present, whether a company
or an individual may be likely to consider a
such a contract, I have no information; but
judging from what has taken place in various
parts of the empire, it would seem to be quite
possible, that if the government be deemed
likely to be willing to make tenders for the right to
contract and maintain the improvement with the
right to charge certain limited rates for the carrying
of cargo, freight, and passengers.

It may be seen from the foregoing statement
of the difference in the cost of transportation, under
different specified circumstances, that the limit
of rates must have to be arranged with reference
to the extent and kind of business to be
accommodated.
Having special reference to the annual amount of the tonnage, and number of passengers. And, as the business is not likely to jump suddenly from a comparatively small tonnage to a larger tonnage, all of the steamboats and sloops are referred to as necessary to ensure weekly trips on the whole length of the navigation. This must not be at once placed upon the river, since such a course would undoubtedly involve dead capital, and loss.

It is to be borne in mind, that not all of the present tonnage along the river will remain in barcas and canoes, will become part of the freight of the steamboat and barge system; because much of it is local freight, of provisions, etc., of a kind likely to be shipped to the sea coast, and because for a few years at least the trips of the steamboat line might not be frequent enough to warrant dispensing entirely with the present barca system.

The Railway Connection with River Current.

If so happens, that the new improvement and transportation on the improved navigation, must be coincided in conjunction with transportation on the Portage Railway around the St. Mary's Falls, etc., without the opening and use of that railway, it is somewhat questionable whether steamboat transportation on the Upper river could be made profitable. If the future connexions between the upper and lower river were to be confined, as now, to carriage by pack-animals, that would constitute almost a blockade. It would be insufficient to alter the navigation of cut-off systems along the upper river, and very little public benefit would arise from the improvement of the navigation.

The Railway Connection with River Current.
It is therefore taken for granted that the railway from Piranhas and Jabotá, which is now well advanced, will be completed, and run in connection with the steamboat navigation on the Upper river.

It again without any improved rail, affording a steamboat navigation from Jabotá, the railway owned by Company B, unless, during a large portion of the year, and perhaps at all times, there would have to be a transhipment from railway to river, and vice versa at Jabotá.

It is therefore very clear that the railway and the improved river are mutually complementary, and that neither without the other, would be prone or less a wasteful expenditure.

Upon the railway, 114 kilometers in length, between Piranhas and Jabotá, it will be easy to transport all the freight and passengers for a very much larger traffic than any herein referred to. If there were no more than 250 tons, each way per week, a single locomotive could carry, by running 4 days per week:

One locomotive running from Piranhas to Jabotá one day, and returning the next, making 3 trips a week, would have to take only 83 tons per trip, each way, to do it easily; and yet in a year this would amount to 13,000 tons each way, or in all, once on the road, 26,000 tons, equal to 1,820,000 axeas. Dated this quantity of 300 tons each way per week, would demand two locomotives making, each, 3 round trips per week; and a steamer with 2 loaded cargos starting and arriving semi-weekly at Jabotá, would do the same amount.

It is not intended by any of these calculations to assign limits to the trade likely to arise...
upon the completion of the two improvements, the railway and navigation, they are more presented as aids in the study of the financial question involved.

Calling the railway 120 Kilometers long, a charge of 100 reis per Kilometer, free truy, would be 12,000,000 Tons at 12,000 per ton amounts to 312,000,000 reis per annum.

For passengers each way 2000, would give 2000 passengers each way per annum, or 4100, one way. 4100 passengers at 6,000 each, would be 24,600,000 reis.

Making a year's receipts on the railway, upon this foregoing assumption, 336,000,000 reis.

Although the circumstances of the Sáo Francisco River Valley are peculiar, they are not so peculiar as to prevent entirely the application of general experience throughout the world, when improved land and transit have been opened. No matter the quality or alignment. The amount of freight transported and traffic of goods, and it is only reasonable to assume that a few years after the opening of the improvements under consideration, the business from the Upper Sáo Francisco will be much more important than it is at present.
Agriculture, Irrigation, Minerals, etc.

In the valley of the Upper San Francisco, Agriculture is now carried on just as it was a hundred years ago, and by the same kind of people. Owing to the peculiar physical characteristics of the climate and of the river, the Comparative isolation from the rest of the Empire, and the want of a proper Commercial Connection with the outer world, there has been very little inducement to change the ancient routine. Only such cultivation as could be easily conducted without the aid of modern improved implements of husbandry has therefore been introduced. Farming, in the ordinary meaning of the term, is yet unknown. The how and the axe being like the only implements. Ploughs, harrows, rakes, scythes, wagons, barns, etc., which usually belong to farming in other countries have not been introduced. Nor could they be introduced with much advantage without a radical change in the Customs of the inhabitants.

These Customs, long ago established, are partly the result of the manner in which this valley was first opened to Civilization by the Jesuit Fathers, and also largely to the anomalous climate, which obliges the people, who knew nothing of "farming," to depend almost entirely for their support upon the cultivation of a limited scale, of only those lands which are annually inundated by the rains, together with the islands and immediate borders of the stream. There can be no doubt that these anomalous circumstances have fixed the nature of the prevailing occupation, and habits of a large proportion of the present inhabitants, chiefly descendants of the original Indians and succeeding Negro
population. The comparatively small number of White men in the towns and upon the Mission number of fazendas, while the laws of Crown Contributions to the upkeep of Civilization Customs, have materially changed the old system of Cultivation.

By far the greater portion of the produce is raised upon numerous, very small, ruin plantations, each one generally managed by a single family. Sometimes there are several families or parties of families in one house, and there are many places along the river banks, on both sides, where there are hamlets of several houses, and often of a considerably greater number. These clusters all have names; which make an imposing show upon the maps. There are besides many small towns, and some considerable villages and cities; so that the banks of the Upper São Francisco are occupied and Cultivated by a large population, almost wholly engaged in agriculture.

Here and there a family has a rough wooden, matted, or near the towns; but usually each one has a canoe or two, in which they convey their small surplus production to the nearest local new market, and which are also used in visiting Neighbors and for general river traveling. Some have in addition a few Cows, horses and mules.

These little plantations, although very numerous, are often not more than two hundred or three hundred meters long, and very narrow, being bounded laterally by the generally limited width of the yearly inundated slope. Upon this small patch, after the subsidence of the floods, the usual products of the valley are raised. Following this gradual subsidence, the families plant Mandioca, corn, beans, sweet potatoes, rice, avocados, a variety of melons, squashes, pumpkins, etc., and in some
place sugar-cane, tobacco, Carter-tul eache, and a little cotton. They cultivate from the high-land line down to low water mark. A distinguished traveler remarked, that the luxuriant growth of vegetation extends down to the water's edge. Do it does; but he omitted to mention, that the only vegetation is between high and low water mark.

A large share of these crops is consumed by the families who reside there; the residue is sold, or exchanged for other articles, coffee, tea, dry goods, etc., at the nearest town. Other money there is mostly found its way to the Coffee of the Merchants, and re-exports, many of whom are also Merchants. The Crews and passengers on the Canoes and Barques that ply along the river, also buy some of the products to replenish their stocks of provisions.

Nearly all of these numerous islands are Cultivated, most of them being subject to overflow annually; and it is common to find a number ofTemporom homes or huts on an island occupied by as many separate families, each working their own particular portion. When the year's floods invade the grounds on the islands the people retire, having as a rule previously gathered their Corps, and seek more elevated ground on the Main land, where they leave other houses or huts. The houses in general are one-storied, with walls composed of sticks and clay, and having natural floors of earth. They are without Chimneys, and have thatched or tiled roofs. The furniture is exceedingly simple and scanty; bedsteads are very rare, hammocks or mats on the ground-floor being in universal use. The climate being very mild, out-door sleeping is quite common. The people rise early and begin work, usually rising an hour or more clearing the heat of the day.
New women and children work in cultivating their little plantations, and the women and children also watch the growing crops, sitting in very small temporary shelters which shield them from the sun. They are compelled to guard against the depredations of Crows, black-birds, hogs, and other destructive animals, and it is said that one Canoe-man and a canoe hands passing on the river will bear watching — although they are极具 charitable, and opposed to being seen taking melons.

One of the occupations of the women is knitting lace, by hand and loom. They are very skilled, they may be seen knitting while watching their crops or tending babies. Children are numerous, and they seem to thrive wonderfully with scarcely any attention. Cultivation, or clothing. Grand-parents, their children, and grand-children are often found in the same diminutive house; and some times the great-grandparents also.

Along some portions of the valley the soil is and near the river banks contain considerable quantities of saltpetre. Here the manufacture of salt occupies a part of the time of the family, who dig the material, bleach it in ox-hides, or rough boxes, and then evaporate the liquid by boiling, and gather the salt. The process is very crude, and the salt is crude and inferior to the import salt; but its manufacture is one of the industries, and although in most cases it is an a small scale in the aggregate a considerable quantity is produced; it, however, enough for the general consumption of the valley, so that many of the families, large and small, buy more or less imported salt. The imported salt has been
Adventures in Piranhas from Vessels, and Carried by pack-trains to the Upper River, and shipped as carcasses or cajas at Alcalá, or at Calabó, to places farther up the Valley. The general movement of salt is up the river; while the general movement of tapiocas, or the Coana sugar cakes, is down the river, chiefly from the tributaries. The salt is for the cattle and other stock, and for salting meat and fish. Salt has also formed part of the commerce from Quito, sent overland on pack trains, a distance of five hundred kilometers to Jauja, and shipped thence along the river. The movement of salt and sugar cakes forms a considerable portion of the New Commerce—resulting from the Agricultural labors of the People of the Valley.

The sites of the comparatively few large fazendas in the immediate river valley have been selected as the most favorable for working plantations on a large scale, with slave-labor. They usually Command a considerable portion of Cultivated land along the river, or on islands convenient, accessible, but there are few Considerable fazendas in the Upper River for a long distance above the Plutus Affine Falls. Rice products for consumption in the Valley are the present staples of these fazendas. To the question why they did not raise rice for shipment out of the Valley, the answer was, that, owing to the great cost of transportation they could not afford to send their products to an outside market.

Pottery, on a small scale, is Carried on in some parts of the Valley; and there is an abundance of excellent clay which forms itself in numerous places along the river banks. There is various Colors, red, white, yellow, etc., kind of California Qualities, some very fine; but as in the case of
other products of the valley, the sales are confined to the valley.

Shaving is one of the industries of the valley; but it has only been introduced to a limited extent, for the reason already assigned. With cheapened transportation, the bezeriers may be extended. The manufacture of a peculiar leather that has been发扬 in the Villa g llastra grande, has generally the leather hats, and coats, etc., worn commonly by the people are made all along the river. Shoe-making is also one of the industries, but a large proportion of the every-day protection for the feet is made by the people themselves, being simply cut from sole-leather and formed into sandals. They are far predominant everywhere. These are worn in every town and villa, where any goods, hand-wares, and provisions are sold. They are generally quite small. In most of the towns, weekly fairs are held. They are attended by the people who come from various points on the river in canoes and bacao, loaded chiefly with food-products: some come in from their plantations on horseback. Carriages, for the conveyance of persons, are uncommon, even in the largest cities on the river. Everywhere the biccus, as a rule, are unembellished, and candy-like the soil around the cities.

In every one there are, comparatively, few well-to-do people, government officers, old merchants, with an occasional physician; but the large majority are quite poor, with very humble wants, barely supplied, who have never known the use of luxuries, and who have not the means to purchase them. We met respectfully, decently-dressed women, past middle-age, who had never previously seen their faces in a looking-glass.
Unless, therefore, some new system shall be introduced, it would seem to be very improbable that a sudden, large increase of demand for accomplished articles can arise; or that there will be an immediate growth of a great commerce from the shipment of such produce, as will bear transportation to distant outside markets. Some will be required to revolutionize the fixed habits of a whole people. At present the major part of the labor of the inhabitants seems to be devoted to the sustenance of the people now living in the valley, and the addition of any number of the same class of cultivators, working and living in a similar way, would add but little to the import or exports.

There is one way in which it may be possible to augment the merchantable production of the immediate Near Valley; namely, by the introduction of artificial irrigation, on such portions as have a good soil, where the natural moisture is at present insufficient to warrant an attempt at cultivation.

Irrigation has been proposed or suggested at various times by different writers, though it has never been fully tried in the San Francisco Valley. The proposition, to "irrigate," at first view seem very simple, but when considered more closely it will be seen that it is complex, in this Valley.
While it is true that there is much land with good soil, in some parts of the Valley, which if irrigated would yield abundant crops, it is also true that a great deal of the soil is too sandy and clay to be worth irrigating.

All of the land that needs irrigation lies above the level of river floods. In some places it is nearly level, in other places it is gently rising, while others it rises rapidly on the foot hills bordering the river. It may be considered that an upper part of the Valley that is annually flooded by the river, does not need artificial irrigation; though at times it becomes very dry for, with proper management the crop can be gathered before the almost sudden tempest injures it. Along the lower half of the Valley of the Upper River a large proportion of new cultivated land is now occupied and cultivated. In the upper half there are larger bodies of cultivated land, not yet cultivated, some of them being too slight, close and about 7 or 8 ordinary low water being very desirable. There is an uncertainty as to securing the crops upon such lands, as they are the first to be flooded, and the last to be free from the water, ready for planting.

Farms, such as are common in Europe and in the United States, do not exist any where in the Valley. There are only plantations, large, and numerous small ones, as already mentioned. It is not practicable to change these plantations, which are wholly dependent upon annual inundations from the river floods, into ordinary farms.

It is to be considered that a large population, depending for their existence upon the crops which these lands produce, already occupy and hold them.

So that any considerable accession of new corners
would be awkward on account of the difficulty of
securing sufficient arable land upon which the addi-
tional population could support themselves during
the period required to establish successful irriga-
tion upon the dry lands.

Before such irrigation should be introduced
in any part of the valley, it would be necessary
to make regular surveys of the particular region
proposed to be irrigated, whether on a small or
on a large scale.

The water must be either pumped up from the
river, or conducted from it through Canals. Along
this new series of Canals, constructed so as to be secure
from injury from the floods, would be run, partly on
account of the great rise of the freshets—often ten
meters, and sometimes thirteen meters. Such
Canals should only be thought of in connection with
irrigation on a grand scale, and not merely
of Canals surveys, having their particular object in
view, and conducted by men of intelligence and
experience. Could decide upon the question of the
admissibility of their adoption. To form a design of the
plan of irrigating by means of Canals taking the
water directly from the river without pumping
would be altogether too expensive. Pumping up water
into small irrigating Canals or ditches, would be the only
feasible plan ordinarily.

In any case, careful surveys should be made
in advance, from which it could be ascertained
how much good land could be irrigated at or near
a given point, the cost of the necessary irrigating
works—pumps and fixtures to the river, pipes, and
the small irrigating Canals or ditches, and the cost
of their maintenance, the amount of crops to be
Calculating upon the cost of their transportation to a
market, and the cash value of the probable
sales, unless a handsome profit could
be reasonably assured, it might be difficult to
obtain the requisite capital for works upon a
comparative scale.

On a small scale, such as individuals,
giving small tracts, might irrigate, wind-
mills would doubtless be the most economical
means to be employed; the pumps being arranged
to pump during the lowest stage of the river,
which occurs during the dry period, when irri-
gation is most needed; though none or less pump-
ing would be required at any other.

It may be deemed certain that no
system of irrigation on the Upper now, on any
scale, large or small, will be undertaken to
long as the stream remains in its present natural
state, without improvement. The people
living in the valley have conformed their
methods of work, and their manner of
living, to the circumstances of the now and
the climate, and the soil—following literally
in the footsteps of their forefathers; so that unless
new and important elements are introduced,
there will be no change, unless it may be a slow,
gradual change, involving the adven of another
Generation.

Only upon the assumption of an improved now,
opening a real highway, and cheapening trans-
portation, and encouraging additional cultivation,
is it at all likely while to consider artificial
irrigation in the San Francisco Valley as an element
of any importance to its agriculture; but with an
Improved now, giving this valley outside market, much may be accomplished by improved methods of cultivation, and by selecting particular crops which may be most profitably shipped. Irrigation may follow, in due time.
Mineral resources, etc.

The natural mineral wealth of the Valley of the San Francisco remains to-day as Nature left it. Although there has been a large population residing along the river for more than a century, the circumstances hitherto mentioned have not tended toward the development of mineral resources. With the exception of the manufacture of lime, on a limited scale and of salt from the saline earths, there has been no attempt to utilize the wealth beneath the soil. Yet it is known that there are valuable deposits of excellent granites, and there may be other valuable ores hidden in the recesses of the numerous unexplored mountains of an extensive region, concerning which so little is known.

Professor Derby, an experienced geologist, who has for some years been studying the geology of the interior of Brazil, accompanied the Commission from the mouth of the river to the Falls of Potopora. He embraced every opportunity to examine the immediate valley, being aided in his labors by the Commission, so far as could be without delaying its general progress up the river. His report may properly be regarded as part of the work of the Commission. It shows that the mine resources, other than agricultural, of the main valley explored by the Commission, and of the Valley of the San Lucas, formed by Professor Derby from its junction with that of the San Francisco, and to Diamante to Darceina, are very important.
Yet the examinations made in 1879-80, added to the information derived from previous explorations, cover but a narrow zone, chiefly those portions in view of the immediate river valley. Some lateral explorations have been made affording a partial knowledge of the geological features of the plateaus and mountains, but there remains a vast unexplored region which may contain mineral deposits of great value. It is not impossible that coal suitable for fuel may be discovered, which, added to the other natural resources, would greatly enhance the commercial value of the valley. It would then be merely a question of time when its mineral wealth could be developed and utilized, when the valley of the São Francisco should become the seat of extensive industries which cannot as yet be undertaken with profit.

The iron ores on the upper São Francisco are of a superior quality, and at several points they are known to occur in large quantities, but there is not sufficient timber for for Cooking, in their immediate neighborhood, nor has coal yet been found. Without an improved river, these great ore deposits, and other analogous deposits that may exist in the numerous mountains, must remain undeveloped and useless; for even if to-day there was opened and in use Railway to the Coast, the distance of Railway Transportation—more than five hundred kilometers, would be a bar against the investment of Capital. It would cost as much money, and money against the investment of Capital in Iron Works in the Valley, unless upon a comparatively small scale for the Supply of the Valley, and the Interior. At present, the Consumption of Iron, compared with the Population, is quite insignificant, and it cannot be large without an essential Change in the general Course of the Valley, which is not at an end, but will take place only if the iron ore shall be imported.
General Industry.

As yet, excluding sugar-making, there are no considerable manufacturing industries in the San Francisco Valley; nor is it at present an inviting field for the investment of capital in the establishing of new industries, for the resources already assigned, and which must be obvious to those who have intelligently studied the Condition of the Country and the Character of the Occupations and Habits of the Inhabitants.

On the other hand, with an improved navigation, extending to commercial advantages, throughout the entire length of this extensive Valley, starting Common trade and travel which do not now exist, it will be contrary to general experience elsewhere if the effect shall not be to modify the habits, and augment the commercial wants of the people, who, up to this time, have been secluded, actually out of the range of the general advance that has been made and is going on in other parts of Brazil. These are regions in the United States which ten years ago were considered too sterile and forbidding to promote any local traffic, while already afford an amount of local trade and travel, arising from the transportation of emu-oes, deer-oes, limestone, line, wood, coal, provisions, merchandise and fowling, fully equal to the large through business. Excellent marble, sand-stone, and granite, for building, and superior limestone for the manufacture of lime, are found at various points in the Valley.

Education, to some extent, in a very moderate scale, is now going on in the more important towns in the Valley, and in the Course of many years it will...
effects will spread and become apparent; but it is a slow movement, in which the great majority of the people cannot directly join; but when this region shall be unlocked, by means of a reliable navigation; when it shall be opened for the passage of steamboats, making frequent; and perhaps in a reasonable time, daily visits to the numerous ports, an impulse will be given to popular education which will hasten the day when the general population may rank with the other more advanced population of Brazil. Miracles should not be promised, or looked for; time is an element in all such Changes.
Directions

For making the final explorations of the Rapids of the São Francisco River, for the selection of Channels to be improved.

1. It is necessary to have a small, light-draft steamboat, which when equipped with wood and water on board, should not draw more than about 0.40, and which should have sufficient power to stem a Current of twelve kilometers per hour.

2. The object is to find a natural Channel among the rapids (if one exists) or a quasi rapid, which may be sufficient for steamboats and barges drawing one meter, during extreme low water; such Channel to be not less than 30 meters wide in the narrowest place, and not less than 1.25 meters deep in the shallowest part. The Channel to be so shaped that a steamboat 40 meters long, with two barges in tow, could make the turn.

If it be found that such a Channel can be obtained at a quasi rapid by blowing up and removing a few rock obstruction,
it may be better to select that one or performed to another requiring clearing of outfalls, and cribs or riprap embankments for artificially augmenting the depth.

Where there may be a choice between the two methods, the selection of the one to be improved will be a matter of judgment, and calculation of cost by the engineer in charge.

In either case, after the selection is made, the work required to be done should be shown on a map, on a large scale, whether to be new obstructions to be removed, outlets to be closed, cribs or riprap embankments to be made, or channels to be constructed.

3. The fact that a natural Channel may have a very irregular, rocky bottom, and ragged, rocky sides, and yet be a good steamboat Channel, if it has sufficient depth, and the turns are not too sudden. In fact, if the velocity be considerable, the friction caused by the above mentioned irregularities, may materially reduce the velocity of the current and improve its navigation. Such Channels can only be properly examined by the use of a steamboat.

4. An improved Channel, 30 meters wide, two meters deep, having a velocity of 16 kilometers per hour, or about 5 meters per second, turned
require a flow of about 420 cubic meters per second, and allowing 25 per cent for waste through the
channel, would be

It is now proposed, nor is it necessary, to treat this
point with accuracy; but merely to keep in mind,
approximately, the general requirement.

5. There may be cases where there is a channel
of good width, with some rock obstructions,
but too shallow
for the assumed navigation; needing, therefore,
little additional depth of water. Additional
water can be admitted into such channel by
a crib or rip-rap jetty at the head. Such
may be preferable; and no other work, or very
little other work may be necessary.

6. In the case of the Sobra do Rio Rapids, the
examinations made by the Hydraulic Commission
in 1879, showed, that the proper plan for that
run of rapids, is the enlargement of the channel
through the Pernambuco side, as it will widen
and lower the water stage and facilitate
the design of the works needed. A jetty.
or projecting crib, or mound of rip-rap at the
upper point of the Island of Cachoeira, will probably
be found necessary to secure an adequate quantity
of water to create sufficient low-water depths, on
the upper portion of the Channel. Since works of cuts or riprap banks, at the shallow points further down, concentrating the natural low water flow, may or may not increase the depth that but little additional water may be needed at the Head. In that case, the effect would be somewhat accordingly, and the cost of improvement lessened. It would in time cost if it were spent in making
examination with the view of Constructing a steamboat channel on the Bahia side of the island of Cachoeira.

In the case of the series of rapids terminating with the "Vale," the examinations of the Hydraulic Commission in 1879, have shown, that there is a choice of routes in the upper portion of the series; while on the lower portion, the Pernambuco side is undoubtedly the proper side to be improved. In case the Pernambuco side should be found generally preferable to the river Channel's new Company navigated, it will be necessary to build a jetty, or crib, or riprap mound at the upper point of the "Vale," in order to narrow more water into the comparatively narrow channel between the island and the Pernambuco side. There are five small, local rapids, in the arm of the river, at which some work will be necessary; where, by building low dams and low Chutes, four navigable Channels may be made, needing only a little clearing of rocks; and the additional flow of water from the head, to make a good Steamboat navigation.
The future final examination of the "new route" from a point opposite Rodulus down to where the main new Channels bear over to the Pernambuco shore, should be made with particular care, not only in order to secure an advantageous low water route but to be certain that the Channel will be safe in higher stages of the river.

Below where the new route strikes the Pernambuco side at the foot of the Island Cãiti, the Channel will extend will be common to all routes from above, and nearly the same amount of work will be required below in either case. The work below the Island Cãiti will consist of the clearing of the fields between islands to prevent waste of water, and the Concentration of a larger flow in one Channel, and at certain points—especially at the Vão, to further Concentrate by low dams and sluice in said Channel.

From the examination already made it seems probable that the route on the Pernambuco side all the way from the head of the Island of Cãiti to the Vão, may prove safer than any outside Channel for all stages of the river; but this point cannot be settled until thorough examination, that be made and the different routes are carefully mapped, and Carefully compared and Compared.

8. While making the examinations with the Steamboat, it would be advantageous to have some practical man in Charge of the boat who has had experience in running Steamboats on Swift rivers; on two accounts: first, to ensure Safety in the Management during the Examinations,
and next to assist by his judgment in deciding upon
the probable safest or proposed channels, in
different stages of the river.

9. In regard to the general conduct of the examina-
tions, preliminary arrangements, preparation of the
bids of materials, contracts, etc.; much will depend
upon the manner in which the work improve-
ment is to be carried out—whether directly, by the
government, or by a Contractor acting under
Government supervision, or by a Contractor.
It is not therefore considered necessary to enter
further into detail at present.
From which to make drawings showing the shape and size of cribs to be used in certain cases for preventing the flow of water out of channels, and in other cases for guiding an additional flow of water into channels.

Similar cribs are to be used for forming artificial channels in a few cases; where it may be found desirable to confine the water to a limited width, and to increase the natural length of the low-water slope.

It is contemplated that generally the cribs for preventing the outflow from channels will be quite low, ranging from 0.50 to 2.50 ft, requiring a width of 2 ft.

Although a width of 2.50 ft is prescribed for cribs from 0.50 to 2.50 ft high, it is known that there can be very little of that height required in the only cases where it is possible to the original plan for guiding additional flow of water into the channel with improved...
It must be understood that these will be but two kinds of work upon the Cribwork; namely, making various Cribs filled with stone, or gravel, and placing Embankments of rough stone.

1st. For diverting water from the main rivers, or from side channels, and the Channele to be improved.

2nd. For stopping natural outlets, to prevent waste water from the Channel to be improved.

3rd. For forming Channels, or guides, to limit the width of the Channel, or to augment the depth and lengthen the slope to diminish the velocity of the Current.

The cost of timber along the Cachoeiras is greater proportionately, than the cost of stone, so that side-trap banks, wherever the Circumstances admit of them, will be used in preference to the Cribs.

Most of the work begins quarrying, delivering rough stone, and constructing it from stones to form the Cribs.

Only the simplest, mechanical skill is required, except in the case of the removal of rock-mixed rocks, when a few men especially skilled, would be needed.

Cost, methods of dealing water, such as might be necessary in a small volume, are not needed here, because there is an abundant flow of water at all times, and the leakage that may occur through the Cribs and banks will not materially affect the navigation.

The Cribs and banks need not be laid down upon the lower surface, because when the river rises it must be allowed to flow freely over them; which will submerge them, and increase the depth of the Channel.

In some cases, where the stone from the Quarries may be very large, it may be found advisable to chop smaller stone, or Crome gravel on the up stream side of the top trap banks, and thus lessen the waste of water.

No great pressure of water will come upon any of the Cribs or top trap banks, because the difference of level of the surface of the water in the two sides and of shifting in most cases, and no height very considerable.
Sketch of earth dam across an
outlet of triangular bottom.
Or of a rough stone embankment as the case may be.

Embankment to extend 2 miles wide on top.
Upstream slope 1 \( \frac{1}{2} \) to 1
Downstream 2 \( \frac{1}{2} \) to 1

Appoximately.
The general plan proposed for the improvement of the Channel between the Ilha da Cachoeira and the Bomandura shore, includes the Construction of a Jetty (of wood and masonry) at the head of the Island to allow a large additional quantity of water from the Main River into this Channel.

This will be the principal work; the additional depth of water to be created by this Jetty will render it unnecessary to do any large amount of work between the head and foot of the Island. All that will be needed being some small, partial treads and two Chutes to Concentrate the flow, and the removal of a few rocks to make a safe Steamboat Navigation. It is evident from the landings, that an increase of less than half a meter in the depth of the flow, will require only a moderate amount of work along the Channel to create a minimum depth of 1½ meters. We have seen hundreds landings, in the distance of about 1½ Kilometres and this Channel! All except 98 were over 1 meter: 85 were 1 meter; 8 were ¾ meter; and 5 were 2/3 meter, for very short distances; and some of these were out of the Channel.

The arm of Channel is from 90 to 130 metres wide, generally about 100 metres wide, free from sharp bends between the banks; although some of the principal natural lowwater Channels, for Barcas and Canoes, present sharp turns. These will be avoided in the Arrangement of the Chutes. There is no at any time in any stage of the water a Current strong enough to occasion difficulty to Steamboat-Towing, up this Channel; or even now, without any improvement, with a small jetty raising the water one meter, a Steamboat could navigate it.

Memorandum by Company officers. Cachoeira da Sobradinho.

Cachoeira da Sobradinho.