Terminal do Seixal
Hydro-Morphological Study

figures

February 1982 / P457

PORT AND WATERWAY ENGINEERS
Fig. 2.1.1.: Schematisation of Tagus Estuary
Fig. 2.2.1.: General arrangement sounding charts
Fig. 2.2.3.: Wind Roses at Lisboa
Computed water level curves

- N = 38 M = 19 L1 Terreiro do Paco
- N = 21 M = 42 L5 Seixal
- N = 153 M = 14 L7 Vila Franca

Fig. 2.4.1.: Tagus Estuary Mean Spring Tide
Computed waterlevel curves

- N = 28 M = 18  L2 Cacilhas
- N = 46 M = 48  L6 Montijo Base
- N = 64 M = 20  L9 Cabo Ruivo

Fig. 2.4.2.: Tagus Estuary Mean Spring Tide
Computed waterlevel curves

- - - - - - - N = 32 M = 35 station 223
- - - - - - - N = 25 M = 28 station 224
- - - - - - - N = 24 M = 43 station 225

Fig. 2.4.3.: Tagus Estuary Mean Spring Tide
Computed waterlevel curves

- - - - - - - - N= 20  M= 41  station 226
- - - - - - - - N= 30  M= 24  station 227
- - - - - - - - N= 25  M= 48  station 228

Fig. 2.4.4.: Tungs Estuary Mean Spring Tide
Waterlevel at station: L1 Terreiro do Paco

- - - - computed at N= 38 M= 19
--- measured July 2nd 1981
- - - - measured April 18th 1973
- - - - measured April 19th 1973

Fig. 2.4.5.: Tagus Estuary Mean Spring Tide
Water level at station: L2 Cacilhas

- - - computed at N= 28 M= 18

- - - measured March 18th 1973

- - - measured March 19th 1973

Fig. 2.4.6.: Tagus Estuary Mean Spring Tide
Waterlevel at station: L5 Seixal

computed at N= 21 M= 42

measured July 2nd 1981

Fig. 2.4.7.: Tagus Estuary Mean Spring Tide
Waterlevel at station: L7 Vila Franca

- - - - - - - - - - computed at N=153 M= 14
- - - - - - - - - - measured March 18th 1973
- - - - - - - - - - measured March 19th 1973

Fig. 2.4.8.: Tagus Estuary Mean Spring Tide
Computed velocity curves

--- --- N = 28 M = 18 L2 Cacilhas
--- --- N = 46 M = 48 L6 Montijo Base
--- --- N = 64 M = 20 L9 Cabo Ruivo

Fig. 2.4.9: Tagus Estuary Mean Spring Tide
Computed velocity curves

--- N= 32 M= 35  station 223
--- N= 25 M= 28  station 224
--- N= 24 M= 43  station 225

Fig. 2.4.10.: Tagus Estuary Mean Spring Tide
Computed velocity curves

- - - - - - - \( N=20 \)  \( M=41 \)  station 226
- - - - - - - \( N=30 \)  \( M=24 \)  station 227
- - - - - - - \( N=25 \)  \( M=48 \)  station 228

Fig. 2.4.11.: Tagus Estuary Mean Spring Tide
Velocity curve at station: 30
- - - computed at N= 70 M= 32
- - - measured June 12th 1972

Fig. 2.4.12.: Tagus Estuary Mean Spring Tide
Velocity curve at station: 36

--- computed at N= 35 M= 25

--- measured October 12th 1973

Fig. 2.4.13.: Tagus Estuary Mean Spring Tide
Velocity curve at station: 223

computed at N= 32 M= 35

measured April 6th 1981

measured 2m-surface April 6th 1981

Fig. 2.4.14.: Tague Estuary Mean Spring Tide
Velocity curve at station: 224

- - - computed at N = 25 M = 28
--- measured 1m+floor April 6th 1981
--- measured 2m-surface April 6th 1981

Fig. 2.4.15.: Tagus Estuary Mean Spring Tide
Velocity curve at station: 225

- - - - computed at N= 24 M= 43
- - - - measured 1m+floor April 6th 1981
- - - - measured 2m-surface April 6th 1981

Fig. 2.4.16.: Tagus Estuary Mean Spring Tide
Velocity curve at station: 226 (Seixal)  

- - - computed at N = 20 M = 41  
- - - measured 1m+floor July 2nd 1981  
- - - measured 2m-surface July 2nd 1981  

Fig. 2.4.17: Tagus Estuary Mean Spring Tide
Velocity curve at station: 227

- computed at N= 30 M= 24
- measured 1m+floor April 6th 1981
- measured 2m-surface April 6th 1981
Velocity curve at station: 228 (Rio Coiao)

- - - computed at N= 25 M= 48
- - - measured 1m+floor July 2nd 1981
- - - measured 2m-surface July 2nd 1981

Fig. 2.4.19.: Tague Estuary Mean Spring Tide
scale 1 : 150000

Computed flowfield: 6 hours after HW at LISBOA

↑ velocity = 1.20 m/s
↓ velocity = 0.60 m/s
□ land node
■ dry shoal node

Fig. 4.2.20.: Tagus Estuary Mean Spring Tide
scale 1 : 150000

Computed flowfield; 9 hours after HW at LISBOA

* velocity = 1.20 m/s
* velocity = 0.60 m/s
• land node
• dry shoal node

Fig. 4.2.21.: Tagus Estuary Mean Spring Tide
scale 1:150000

Computed flowfield: 12 hours after HW at LISBOA

↑ velocity = 1.20 m/s
↓ velocity = 0.80 m/s
square: land node
circle: dry shoal node

Fig. 4.2.22: Tagus Estuary Mean Spring Tide
scale 1 : 150000
Computed flowfield; 15 hours after HW at LISBOA

* velocity = 1.20 m/s
* velocity = .60 m/s
□ land node
□ dry shoal node

Fig. 4.2.23: Tagus Estuary Mean Spring Tide
Computed waterlevel curves

- N = 38  M = 19  L1 Terreiro do Paco
- N = 21  M = 42  L5 Seixal
- N = 153  M = 14  L7 Vila Franca

Fig. 2.4.24.: Tagus Estuary Mean Neap Tide
Computed waterlevel curves

- N = 28 M = 18  L2 Cacilhas
- N = 46 M = 48  L6 Montijo Base
- N = 64 M = 20  L9 Cabo Ruivo

Fig. 2.4.25.: Tagus Estuary Mean Neap Tide
Waterlevel at station: L2 Terreiro do Paco

- - - - computed at N = 38 M = 19
- - - - measured March 13th 1973
- - - - measured March 25th 1973

Fig. 2.4.26. Tagus Estuary Mean Neap Tide
Waterlevel at station: L2 Cacilhas

- - - - - computed at N= 28 M= 18
- - - - - measured March 25th 1973

Fig. 2.4.27.: Tagus Estuary Mean Neap Tide
Computed velocity curves

--- N= 32 M= 35 station 223
--- N= 25 M= 28 station 224
--- N= 24 M= 43 station 225

Fig. 2.4.28.: Tagus Estuary Mean Neap Tide
Computed velocity curves

- N= 20 M= 41 station 226
- N= 30 M= 24 station 227
- N= 25 M= 48 station 228

Fig. 2.4.29.: Tagus Estuary Mean Neap Tide
Velocity curve at station: 223

- - - - computed at N=32 M=35
- - - - measured 1m+floor April 13th 1981
- - - - measured 2m-surf. April 13th 1981

Fig. 2.4.30.: Tagus Estuary Mean Neap Tide
Velocity curve at station: 224

- - computed at $N = 25$ $M = 28$
- - measured 1m+floor April 13th 1981
- - measured 2m-surf. April 13th 1981

Fig. 2.4.31.: Tagus Estuary Mean Neap Tide
Velocity curve at station: 225

- - - - computed at $N = 24 \ M = 43$
- - - measured 1m+floor April 13th 1981
- - - measured 2m-surf. April 13th 1981
Velocity curve at station: 226

- - - computed at N= 20 M= 41
- - - measured 1m+floor April 13th 1981
- - - measured 2m-surf. April 13th 1981

Fig. 2.4.33.: Tagus Estuary Mean Neap Tide
Velocity curve at station: 227

- - - - - computed at N= 30 M= 24
- - - - - measured 1m+floor April 13th 1981
- - - - - measured 2m-surf. April 13th 1981
scale 1:150000
Computed flowfield: 9 hours after HW at LISBOA

+ velocity = 1.20 m/s
+ velocity = 0.60 m/s
- land node
- dry shoal node

Fig. 4.2.35.: Tagus Estuary Mean Neap Tide
Computed Flow Field: 15 Hours After HW

Scale: 1:15000

Dry shoal node and land node

Velocity = 0.60 m/s
Velocity = 1.20 m/s
Fig. 2.6.1: Mean Spring Tide Pressure Curves

Station 228
N = 3 M = 17
Station 227
N = 62 M = 29
Station 226
N = 19 M = 4

Computed Water Level Curves

TIME (hours)

WATERLEVEL (cm + Datum)
Computed water level curves

- N = 18  M = 15
- N = 28  M = 18
- N = 46  M = 24

Fig. 2.5.2: Mean Spring Tide present situation
Computed velocity curves

- N = 18 M = 15
- N = 28 M = 18
- N = 46 M = 24

Fig. 2.5.3.: Mean Spring Tide present situation
Velocity curve at station: 226 (Seixal)

- --- computed at $N=19\ M=4$
- --- measured 1m-floor April 6th 1981
- --- measured 2m-surface April 6th 1981

Fig. 2.5.4.: Mean Spring Tide present situation
Velocity curve at station 227

- computed at N=62 M=29
- measured 1m+floor April 6th 1981
- measured 2m-surface April 6th 1981

Fig. 2.5.5.: Mean Spring Tide present situation
Velocity curve at station: 228 (Rio Coina)

- - - - computed at N = 3 M = 17
- - - measured 1m+floor July 2nd 1981
- - - - measured 2m-surface July 2nd 1981

Fig. 2.5.6.: Mean Spring Tide present situation
scale 1 : 50000
Computed flowfield: 9 hours after HW at LISBOA
+ velocity = .80 m/s
+ velocity = .40 m/s
○ land node
○ dry shoal node

Fig. 2.5.8.: Mean Spring Tide present situation
scale 1 : 50000

Computed flowfield: 6 hours after HW at LISBOA

* velocity = 0.80 m/s
* velocity = 0.40 m/s
• land node
• dry shoal node

Fig. 2.5.7.: Mean Spring Tide present situation
scale 1 : 50000

Computed flowfield: 12 hours after HW at LISBOA

- velocity = .80 m/s
- velocity = .40 m/s

□ land node
□ dry shoal node

Fig. 2.5.9.: Mean Spring Tide present situation
scale 1 : 50000
Computed flowfield: 15 hours after HW at LISBOA
+ velocity = .80 m/s
+ velocity = .40 m/s
- land node
- dry shoal node

Fig. 2.5.10.: Mean Spring Tide present situation
scale 1: 25000
Computed flowfield: 9 hours after HW 
at LISBOA

↑ velocity = 1.20 m/s
↓ velocity = 0.80 m/s
□ land node
■ dry shoal node
scale 1 : 25000
Computed flowfield: 15 hours after HW
   at LISBOA
   velocity = 1.20 m/s
   velocity = 0.60 m/s
   land node
   dry shoal node (blanc symbol)

Fig. 8.5.18.: Mean Spring Tide present situation
Computed water level curves

N = 19  M = 4
station 226
N = 62  M = 29
station 227
N = 1  M = 17
station 228

Fig. 2.6.14: Mean Spring Tide in channel
Computed velocity curves

--- N= 19  M= 4  station 226
--- N= 62  M= 29 station 227
--- N= 3  M= 17 station 228

Fig. 2.5.15.: Mean Spring Tide 12 m channel
Computed velocity curves

- - - - - N = 18 M = 15
- - - - - N = 28 M = 18
- - - - - N = 46 M = 24

Fig. 2.5.16.: Mean Spring Tide 12 m channel
scale 1 : 50000

Computed flowfield: 9 hours after HW at LISBOA

+ velocity = 0.80 m/s
+ velocity = 0.40 m/s
land node
dry shoal node

Fig. 3.5.17.: Mean Spring Tide 12 m channel
scale 1 : 50000

Computed flowfield: 12 hours after HW at LISBOA

+ velocity = .80 m/s
+ velocity = .40 m/s
a land node
a dry shoal node

Fig. 2.6.18.: Mean Spring Tide 12 m channel
scale 1 : 50000

Computed flowfield: 15 hours after HW
at LISBOA

+ velocity = .80 m/s
+ velocity = .40 m/s
* land node
* dry shoal node

Fig. 2.5.19.: Mean Spring Tide 12 m channel
scale 1: 25000
Computed flowfield: 9 hours after HW at LISBOA

↑ velocity = 1.20 m/s
↓ velocity = .60 m/s
land node
dry shoal node (blanc symbol)
scale 1: 25000
Computed flowfield; 15 hours after HW
at LISBOA

↑ velocity = 1.20 m/s
↓ velocity = .60 m/s
square node
  dry shoal node (blanc symbol)
Computed water level curves

- \( N = 19 \), \( M = 4 \)  
  station 226

- \( N = 62 \), \( M = 29 \)  
  station 227

- \( N = 3 \), \( M = 17 \)  
  station 228

Fig. 2.5.22.: Mean Middle Tide 12 m channel
Computed water level curves

--- N= 18 M= 15
--- N= 28 M= 18
--- N= 46 M= 24

Fig. 2.5.23.: Mean Middle Tide 12 m channel
Computed velocity curves

--- N= 19 M= 4  station 226
--- N= 62 M= 29  station 227
--- N= 3 M= 17  station 228

Fig. 2.5.24.: Mean Middle Tide 12 m channel
Computed velocity curves

--- N = 18 M = 15
--- N = 28 M = 18
--- N = 46 M = 24

Fig. 2.5.25.: Mean Middle Tide 12 m channel
scale 1 : 50000
Computed flowfield: 9 hours after HW at LISBOA

+ velocity = 0.80 m/s
+ velocity = 0.40 m/s

Fig. 2.5.36.: Mean Middle Tide 12 m channel
Fig. 2.6.27: Mean Middle Riche 12 m channel

at LISBOA

Computed Flowfield; 15 hours after HW

Scale I: 50000
scale 1: 25000
Computed flowfield: 9 hours after HW at LISBOA

↑ velocity = 1.20 m/s
↓ velocity = 0.60 m/s
☐ land node
dry shoal node (blanc symbol)
scale 1 : 25000
Computed flowfield; 15 hours after HW
at LISBOA

velocity = 1.20 m/s
velocity = 0.60 m/s

land node
dry shoal node (blank symbol)
Computed waterlevel curves

- N= 19 M= 4 station 226
- N= 62 M= 29 station 227
- N= 3 M= 17 station 228

Fig. 2.5.30.: Mean Neap Tide 12 m channel
Computed waterlevel curves

--- N = 18 M = 15
--- N = 28 M = 18
--- N = 46 M = 24

Fig. 2.5.31.: Mean Neap Tide 12 m channel
Computed velocity curves

- N= 19 M= 4  station 226
- N= 62 M= 29  station 227
- N= 3 M= 17  station 228

Fig. 2.5.32.: Mean Neap Tide 12 m channel
Computed velocity curves

- - - - - - N = 18 M = 15
- - - - - - N = 28 M = 18
- - - - - - N = 46 M = 24
scale 1 : 50000

Computed flowfield: 9 hours after HW at LISBOA

* velocity = .80 m/s
* velocity = .40 m/s
- land node
- dry shoal node

Fig. 2.5.34.: Mean Neap Tide 12 m channel
scale 1 : 50000
Computed flowfield: 15 hours after HW at LISBOA

• velocity = .80 m/s
• velocity = .40 m/s
□ land node
□ dry shoal node

Fig. 2.5.35. Mean Neap Tide 12 m channel
scale 1: 25000
Computed flowfield: 9 hours after HW
at LISBOA

↑ velocity = 1.20 m/s
↓ velocity = .60 m/s
o land node
dry shoal node (blanc symbol)
scale 1: 25000
Computed flowfield: 15 hours after HW
at LISBOA

\[ \uparrow \text{velocity} = 1.20 \text{ m/s} \]

\[ \uparrow \text{velocity} = 0.60 \text{ m/s} \]

\[ \text{land node} \]

\[ \text{dry shoal node (blanc symbol)} \]
Fig. 2.5.38.: Mean Spring Tide 14 m channel
Computed water level curves

- N = 18  M = 15
- N = 28  M = 18
- N = 46  M = 24

Fig. 2.5.39: Mean Spring Tide 14 m channel
Computed velocity curves

- N = 19 M = 4  station 226
- N = 62 M = 29  station 227
- N = 3 M = 17  station 228

Fig. 2.8.40: Mean Spring Tide 14 m channel
Computed velocity curves

- - - - - - N= 18 M= 15
- - - - - - N= 28 M= 18
- - - - - - N= 46 M= 24

Fig. 2.5.41: Mean Spring Tide 14 m channel
scale 1 : 50000

Computed flowfield: 9 hours after HW at LISBOA

+ velocity = .80 m/s
- velocity = .40 m/s

Fig. 2.5.42.: Mean Spring Tide 14 m channel
scale 1 : 500000

Computed flowfield: 12 hours after HW at LISBOA

+ velocity = 0.80 m/s
+ velocity = 0.40 m/s

land node
dry shoal node

Fig. 2.5.43.: Mean Spring Tide 14 m channel
scale 1 : 50000

Computed flowfield: 15 hours after HW at LISBOA

+ velocity = .80 m/s
+ velocity = .40 m/s
● land node
● dry shoal node

Fig. 2.5.44.: Mean Spring Tide 14 m channel
Computed flowfield; 9 hours after HW at LISBOA

- $\uparrow$ velocity = 1.20 m/s
- $\downarrow$ velocity = 0.60 m/s
- land node
- dry shoal node (blanc symbol)
scale 1: 25000
Computed flowfield: 15 hours after HW at LISBOA

\[ \text{velocity} = 1.20 \text{ m/s} \]

\[ \text{velocity} = 0.60 \text{ m/s} \]

\( \square \) land node
\( \square \) dry shoal node (blanc symbol)
scale 1:150000

Computed significant waveheight; $U_w = 10 \text{ m/s}$

- significant waveheight = .50 m
- significant waveheight = .25 m
- land node
- dry shoal node

Fig. 3.3.1: Computed Wave Heights Tagus Estuary
scale 1 : 150000

Computed significant waveheight: $U_w = 10 \text{ m/s}$

- significant waveheight = 0.50 m
- significant waveheight = 0.25 m
- land node
- dry shoal node

*Fig. 3.3.2.: Computed Wave Heights Tagus Estuary*
scale 1 : 150000

Computed significant waveheight: \( U_w = 10 \text{ m/s} \)

- significant waveheight = .50 m
- significant waveheight = .25 m
- land node
- dry shoal node

Fig. 3.3.3.: Computed Wave Heights Tagus Estuary
scale 1 : 150000

Computed significant waveheight: $U_w = 10 \text{ m/s}$

- significant waveheight = 0.50 m
- significant waveheight = 0.25 m
- land node
- dry shoal node

Fig. 3.3.4: Computed Wave Heights Tagus Estuary
scale 1 : 150000

Computed significant waveheight: $U_w = 10 \text{ m/s}$

- significant waveheight = .50 m
- significant waveheight = .25 m
- land node
- dry shoal node

Fig. 3.3.5.: Computed Wave Heights Tagus Estuary
BIJKER FORMULA

SEDIMENT CALCULATED WITH BIJKER

\( \theta = 4.00000 \quad D_{50} = 0.150000 \times 10^{-4} \quad D_{90} = 0.100000 \times 10^{-3} \quad RIPPLE = 0.200000 \)

CORRELATION = 0.783449

**FIGURE 4.1.3:** Calibration of Sediment Transport Formula

**MEASURED TRANSPORT (KG/SEC)**

**CALCULATED TRANSPORT (KG/SEC)**
SEDIMENT CALCULATED WITH ACKERS-WHITE
DS0 = .100000E-03  D90 = .300000E-03  RIPPLE = .500000E-01
CORRELATION = .366058

Fig. 4.15: Calibration of Sediment Transport Formula

Calculated Transport (kg/sec) vs. Measured Transport (kg/sec)
DATA SIDERURGIA

SEDIMENT CALCULATED WITH ENGELUND-HANSEN
DS0 = 0.50000E-04 D90 = 0.15000E-03 RIPPLE = 0.20000E-01
CORRELATION = 0.371979
Fig. 4.1.9.: Calibration of Sediment Transport Formula
SEDIMENT CALCULATED WITH POLYNOME
COEFF. ARE: -.560000E-01  .774000  .000000E+00  .000000E+00
          .000000E+00  .000000E+00  .000000E+00  .000000E+00
CORRELATION= .652332
SEDIMENT CALCULATED WITH POLYNOMIAL

COEFF. ARE: -2.40000E-01  5.44000  3.40000  0.00000E+00
          0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00

CORRELATION = 0.658383
BIJKER FORMULA: WATERDEPTH=SM

Fig. 4.1.18: Calibration of Sediment Transport Formula

Transport (kg/s)

0.00

0.20

0.40

0.60

0.80

1.00

0.00

0.20

0.40

0.60

0.80

1.00

Velocity (m/s)

H=0.5 T=3
H=0 T=0
H=1 T=4
H=1 T=2

FIGURE 4.1.18
Bjerr Formula: Water Depth = 10 M

Transport (KG/S)

Velocity (m/s)

Fig. 4.1.14: Calibration of Sediment Transport Formula

Figure 4.1.14
Fig. 4.1.16: Locations of bottom samples
SEDIMENTATION WITHOUT CHANNEL SPRINGTIDE

scale 1 : 50000

* erosion of 100 cm or more
  - erosion of 50 cm
  * sedimentation of 100 cm or more
  * sedimentation of 50 cm

Fig. 4.2.1.: Computed Sedimentation
SEDIMENTATION WITH 12 m CHANNEL SPRINGTIDE

scale 1 : 50000
- erosion of 100 cm or more
- erosion of 50 cm
- sedimentation of 100 cm or more
- sedimentation of 50 cm

Fig. 4.2.2.: Computed Sedimentation
SEDIMENTATION WITH 12 m CHANNEL MEAN TIDE

scale 1 : 50000

- erosion of 100 cm or more
- erosion of 50 cm
- sedimentation of 100 cm or more
- sedimentation of 50 cm

Fig. 4.2.3.: Computed Sedimentation
SEDIMENTATION WITH 12 m CHANNEL NEAP TIDE

scale 1 : 50000
- erosion of 100 cm or more
- erosion of 50 cm
* sedimentation of 100 cm or more
* sedimentation of 50 cm

Fig. 4.2.4.: Computed Sedimentation
SEDIMENTATION WITH 14 m CHANNEL SPRINGTIDE

scale 1 : 50000

* erosion of 100 cm or more
. erosion of 50 cm
* sedimentation of 100 cm or more
. sedimentation of 50 cm

Fig. 4.2.5.: Computed Sedimentation
Fig. 4.2.6.: location of the channel sections
Fig. 8.2.1: Tidal Window
MAX FLOOD AT SPRING TIDE

ships  70,000 dwt channel depth 14m
wind direction: 0 degrees.
wind speed: 0 knots.
MAX EBB AT SPRING TIDE
ships 70,000 dwt channel depth 14 m
wind direction 315 degrees
wind speed 30 knots.
Fig. 5.7.1: Proposed channel width alignment
Fig. 6.7.2.: Alternative proposed basin and jetty configuration